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WATER-BORNE DISEASES.

BY

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[Read January 8th, 1896.]

MR. PRESIDENT AND GENTLEMEN: In the consideration of problems pertaining to the protection of the public health two facts must be kept constantly in view: first, the increasing density of population; and second, the continual movement of the population. The dangers due to infectious disease germs are thereby slowly augmented by importation and by the difficulty of tracing outbreaks. A further danger is the increase of squalor in large centers of population, which favors the direct transmission of disease germs from one person to another. Hence the watchfulness of public health officials must continue to grow rather than to relax, and the laws and regulations designed to maintain public health must become more and more rigid. The movement of scientific discovery does not tend towards the establishment of an automatic public health machine, but insists on greater care, greater watchfulness, more restriction, more expenditure, and more training on the part of those entrusted with this work, simply because of a growing complexity of the social

organism. Possibly some great war would furnish a splendid opportunity for us to see the dogs of disease let loose on the community. The increase of typhoid, the spread of small-pox, the importation of cholera and the appearance of typhus and new diseases would show what we do not now see so plainly in times of peace, the great but quiet and mostly frictionless work of sanitary organization in holding the reins of a number of restive disease germs, whose power over society is by no means extinct, but on the other hand, even greater than before, owing to a certain deterioration of the physical man whose vigor is paid as a price for our civilization.

Water as an important food of the human race is peculiarly liable to deterioration under prevailing conditions, and must of necessity demand increasing watchfulness and a continual readjustment of restrictions governing its use. Its dangers differ from those of other foods in several respects. It is above all a raw food, while perhaps five-sixths of all our other food is sterilized before use. Again, it is a vehicle which drains large territories, and hence may bring together disease germs from a large watershed. It plants its foci of disease throughout a city, and the subsequent extension of such foci will depend upon various factors. In an over-crowded tenement one case of disease may give rise to many others by direct infection. In the home of the well-to-do every precaution is taken to isolate the patient, to disinfect the feces, and thus to prevent an extension of the disease to others in the household or to the water courses, which, unfortunately, are only too often the sources of drinking water for other communities.

The importance of drinking water for good or for evil is not underestimated nowadays, and the activity of investigators the world over is something phenomenal, and will probably continue so in the future. It is my intention today to present among a few new facts mainly such as are already well known. There is always much skepticism concerning current facts, and a reiteration of the more important ones from slightly different points of view with additional proofs is likely to remove skepticism and promote their practical application.

Investigations up to the present have strengthened more and more the standpoint that water is a carrier of certain infectious diseases, having their primary seat in the digestive tract. They furthermore have shown that water is not the only primary carrier of these dis-

eases, and that other agencies, such as raw foods, may be concerned. Furthermore, direct infection from person to person probably plays a much more important part than has hitherto been assumed. Water, therefore, has its place among the carriers of certain infections, but not a supreme or an exclusive place, and this should be kept carefully before us. It is probably not at all concerned in the distribution of many infectious diseases, such as tuberculosis, diphtheria and the eruptive diseases. Evidence is pretty conclusive that micro-organisms producing typhoid, Asiatic cholera, dysentery and diarrhœal diseases are often carried in drinking water.

As an illustration, let us take Asiatic cholera, not because it is likely to invade our territory in the near future, but because as an exotic disease its dissemination is more easily traced than a disease like typhoid, with which civilized countries are now saturated.

The localistic theory of Pettenkofer, with which you are perhaps all familiar, made the ground a certain factor in the development of the pathogenic properties of the cholera germ. Basing himself on an immense amount of statistical evidence, he found that certain towns were insusceptible to this disease, and others were always attacked when the opportunity was offered. From these facts he concluded that the cholera germ had to undergo certain changes in the environment, more particularly the soil, before it became infectious again, and that certain localities were better fitted than others to produce these changes. When Koch began his investigations of cholera, his biological training took him in a different direction. He was led to consider cholera as a contagious disease, transmissible from one person to another, and from one community to another, without any intermediate preparatory changes in the soil or in the water. This view he pushed with a great deal of energy in spite of much opposition. It is mainly to his efforts that the view that water may be a vehicle of infection is now predominant. Although that view was held more or less before his time, yet he was its most vigorous supporter and presented the largest number of facts in its defence.

The view held by Koch that the primary vehicle of the cholera spirillum is water, was quite thoroughly confirmed by the Hamburg epidemic of 1892. To ward off the persistent encroachments of this disease since then, the German government made extensive efforts in 1893 and 1894 along the lines laid down by Koch to suppress the

disease along its boundaries. Bacteriological laboratories were busy during the summer months examining thousands of specimens of water and of stools to trace the presence and the movements of the cholera germs. One important fact discovered by this extensive investigation is that cholera travels mainly along the river courses. It was found that it moves up the river, and that the carriers of the germ were mainly people who are engaged upon the river and who drink water from it. Some cases very strikingly demonstrated this view. One mentioned in the official reports is that of a boy who fell into the river at Berlin and swallowed a considerable quantity of water, and who, although perfectly well at the time of the accident, was taken down with cholera on the following day. This occurrence may be regarded equivalent to a laboratory demonstration of the function which drinking water bears when cholera is prevalent.

By the energetic measures of the German government, cholera was stopped from traveling far beyond the boundaries of the empire, and this success was simply due to the fact that water courses were regarded as the primary carriers of infection, and that persons who moved back and forth on the rivers were carefully watched, and at the first indications of disease quarantined.

The transmission of typhoid fever has been very much discussed of recent years. It is endemic in all civilized countries, and hence occupies the attention of sanitarians to a large degree. It also is a disease which may be carried by water. The conditions favoring the dissemination of typhoid are much more complicated than those favoring cholera, because the infection is present everywhere, and carried by people who are likely to deposit it in various places before it is known, and by whom an epidemic may be started without any recognition of the source of infection on the part of health authorities. The tracing of typhoid outbreaks will be more and more complicated in the future unless recent bacteriological developments help us in the study of this disease—that is to say, enable us to determine the presence of these bacteria in the intestinal tract of human beings and in water. Our inability to do this has been our difficulty in the past. But I shall refer to this matter again in the course of my remarks.

There are two other water-borne diseases not at all uncommon in civilized countries which cause a great deal of trouble in a small way —I refer to diarrhœal and dysenteric diseases. There is no doubt

that they may be conveyed by water, and probably are largely so conveyed. But there are other causes of such troubles that may be overlooked. One of them is the infection of milk; another is the infection of meat with the disease germs of animals.

If we take a general survey of the subject of water as a carrier of infection we will discern what most of us have held for a number of years, that all sewage-polluted water must be regarded as dangerous, whether there is any active typhoid on the watershed or not. It is highly probable that the water receiving the sewage of large communities always contains the typhoid fever germ in larger or smaller numbers, because in large cities typhoid fever does not seem to die out completely at any time. We have as an illustration a city not very far from here, in an adjoining state, which has long drawn its water supply from a large river, which receives the sewage of forty or fifty thousand people six miles above its intake. I had something to do with the examination of the water four or five years ago, and the number of fecal bacteria in that water was very large. As a result the typhoid mortality is very high. Four years ago not only was typhoid very extensive, presenting such various forms that physicians were often in doubt as to the diagnosis, but there appeared simultaneously a winter epidemic of diarrhœal diseases which was undoubtedly favored by the concentration of the sewage-polluted water in the winter months.

The argument which people who use such water present is usually that they have drunk the water for thirty or forty years and are still well. This argument which is presented to us at all times is based on a number of fallacies. In the first place, there is a popular conception, which it is difficult to eradicate, that the water itself deteriorates, and not that something infectious is put into it, which may be put into it in larger and larger numbers as the concentration of the population increases. It seems to me that a campaign of education on the subject of germ diseases amongst those people who have charge of the affairs of our cities, would be most valuable and most timely. They do not realize that the population is continually increasing, that there is a continual movement of population by which disease is brought from outside and the water infected long before suspicion is aroused. Nor is it sufficiently appreciated that many persons who drink polluted water are not affected because they are

insusceptible, or because they have become vaccinated or protected by mild attacks which were not recognized as typhoid.

Another disease which has been considered as water-borne is malaria. This disease, of course, arouses considerable interest nowadays, because it has slowly extended into communities which were hitherto free from it. The literature of the subject is voluminous, and the writers divide themselves into several camps, one of them claiming that malaria can be carried by water, another that it cannot, and a third that water is one of the carriers among several. In general it seems to me, after reading much that has been written upon the subject in medical journals, that those who hold that water is not the carrier of malaria have the better of the argument at the present time. Malaria is a disease which is caused by a specialized disease germ. This lives in the red blood corpuscles, and probably cannot live outside of them, excepting under very special conditions. I doubt very much whether such a germ can have two ways of entering the body, and I think that it probably has developed for itself one way which it must follow or remain outside of the body. If it can be shown, as I think it has been shown abundantly, that malaria is contracted when drinking water is not implicated, I believe that that fact is almost of itself sufficient, until positive evidence is at hand, to counterbalance the argument that malaria is carried in water. There is one thing which largely defeats our observations on the subject of malaria, not so much in this climate as in the climates further south, and that is the latency of the disease in the human body. It is probable that in the southern malarial countries the greater number of people carry the malarial germ in their bodies without any recognizable external manifestations of the disease. Just as soon as such persons expose themselves in one way or another, by indiscretion at the table, by exposure, or by overwork, the malaria appears, not because the infection takes place at that time, but because the infection which had taken place at some distant time was able to gain the upper hand.

Dr. Smart, of the army, who favors the theory that water is a carrier of malaria, writes to a medical journal recently that some of the forts in the south have been greatly improved by the introduction of pure drinking water—distilled water, for instance—and that the number of cases of malaria have been very greatly reduced by this

change. Here, however, permanent infection of the blood cannot be excluded owing to the sub-tropical climate of the stations. Impure water in such cases may act as an exciting cause, by disturbing the digestion, by producing diarrhœal troubles, and thereby give the malarial germ an opportunity to exert its pernicious influence.

If we accept, then, the postulate that drinking water is a vehicle for certain infectious diseases, sometimes denominated filth diseases, we may pass to the question, What means are at hand for estimating the potential or actual dangers of any water supply? We have at least three ways of estimating the sanitary condition of a water. We have, in the first place, inspection; second, the chemical analysis, and third, the bacteriological analysis. Now, I shall not, of course, refer to the matter of inspection, because that is a question which need not be discussed, nor shall I consider the matter of chemical analysis. I wish to limit myself entirely to the question of bacteriological analysis as directed towards the determination of the sanitary condition of a water.

When Koch first discovered, so to speak, the gelatine plate method, he set to work to determine the number of bacteria in various waters. His work established the rule for a time that the number of bacteria in water, as determined by their growth on gelatine plates, was in a way indicative of the relative amount of pollution in the water. This method of numerical determination was carried on for some time, until a current set in against it. Then followed the study of pathogenic germs in water, that is to say, the study of methods by which the pathogenic germs, which are directly concerned with disease, can be brought to light.

From my own point of view I believe that the numerical determination of bacteria in water is of very great value. The main difficulty up to the present has been that we have had insufficient data with which to interpret the results of the bacteriological examination. It was hoped when this method was brought out that any half hour examination would give us full information concerning the quality of the water examined. But this view, of course, which was very superficial, has entirely given way to the view that much more is to be done bacteriologically before we can say anything concerning a water.

The numerical determination of bacteria in water for sanitary purposes is of very great value in surface waters, lakes and rivers,

especially the larger rivers. I believe that up to a certain point the number of bacteria is proportional to the pollution of a river—we cannot say exactly fecal pollution, but it may be pollution from dead organic matter of one kind or another. Thus a dead animal thrown into a stream may for a short time change the bacteriological condition quite materially. The same may be said of all organic impurities of an animal nature, the feces of animals as well as those of human beings. I think that the important thing which should be done at present is to have numerical determinations of bacteria in our large water supplies put on record either daily or semi-weekly. Such a record should be kept for future use, because in the hands of a skilled biologist the interpretation will be very valuable, certainly as valuable as any chemical analysis is ever likely to be. The information to be gained by the periodic counting of bacteria in water is best shown by some illustrations.

For a number of years, beginning in 1884, I had taken considerable interest in the bacteriology of the Potomac water which supplies Washington, and I found year by year that the bacterial curve was almost constant. This curve is peculiar in this, that the number of bacteria is high in winter and falls quite low in midsummer. Another fact of importance is that whenever the water became turbid, which is a characteristic of the Potomac supply after rains, the number of bacteria rose very abruptly. There was a definite relation traceable between the number of bacteria and the suspended matter, so that after a little experience I was able to estimate approximately the number of bacteria in the water by an ocular inspection of the turbidity.

It should be stated, however, that this bacterial curve does not correspond to the typhoid fever curve. The latter is highest in late summer and early autumn, when the former is lowest. The apparent contradiction remains to be explained. It may be attributed to the large importation of typhoid from unsanitary suburbs and summer resorts, possibly to the extensive use of water from the many city wells. The Potomac receives comparatively little sewage, yet the conditions are such that this slight pollution may prove very telling at times when the system is most susceptible and when water is drunk most freely.

Profs. Brown and Stoller, of Union college, made, several years ago, extensive observations on the number of bacteria in the Hudson

river. Taking samples far above sources of pollution, they found the number very low, not much above 50 in a cubic centimeter, I believe. Going down stream the number steadily rose until, below Albany, it reached the figure of 30,000 to 40,000 at times.

The numerical determination is also of importance in tracing imperfections and leaks in a water supply. Perhaps some of you remember the paper of Dr. Shuttleworth, of Toronto. He had studied the water of the lake from which the water supply was taken pretty thoroughly bacteriologically, and from his examinations he decided that something was wrong in the water supply, as the bacteria were growing more numerous. Finally the city authorities were stirred up to look into the matter, and found that a whole section of the conduit had dropped out of place in the water near the shore, and that the supply was therefore being taken from near the shore instead of some distance away where the intake was located.

For wells the interpretation of numbers is not so easy, largely because most of the infection enters at the surface. Wells which are poorly protected at the top will always show a pretty large number of bacteria. This fact I was convinced of by the examination of a large number of wells in Washington. I may state, for the benefit of those of you who are not familiar with that city, that it has over 200 wells distributed throughout the city, which were constructed when the water supply was inadequate, and which are still in use. They are cherished by the population, and if one happens to be removed an appeal to the health officer not infrequently leads to its restoration. I recall one in which I found fecal bacteria several times. The well was closed up, then reopened on account of the clamor of the people living near it, and finally the pump was removed. I was at times struck with the purity (bacteriologically speaking) of some of the well water in the heart of the city, where the surface is quite thoroughly protected from pollution by the asphalt pavement, which prevents the urine and feces of horses from entering the ground. Sometimes I could find not more than from four to twelve bacteria in a cubic centimeter. In other cases, where there was evidently leakage from the surface, the number would run up to 500 and 1,000 in a cubic centimeter.

We all know of what immense value the numerical estimate of bacteria is in determining the efficiency of filters. I will not dis-

cuss this phase of the subject, because there are others here who are better prepared than I am.

Let us now turn briefly to a consideration of the search for pathogenic germs which produce specific diseases, such as typhoid and cholera. I am glad to say that the cholera germ, if it should ever come into this country, can be quite readily detected. The methods of bacteriology have been so advanced in recent years that by certain processes of cultivation the cholera germ may be detected even where it is present in very small numbers in water or stools. Thanks to these methods it was possible to examine thousands of fecal discharges and samples of water from the basin of the Oder, the Vistula and the Elbe in Germany during the past two years, in order to trace the presence of these germs in water, and in the fecal discharges of patients and suspects. It was found by these methods that a great many persons who lived in infected families carried the cholera germ in their intestines without being ill. This point I consider of very great value. It is a matter which one might have anticipated from a bacteriological standpoint some years ago, but now it has been satisfactorily demonstrated. The cholera germ can be carried by persons who are apparently healthy from one place to another and discharged with sewage into streams where multiplication is to all appearances possible.

With typhoid the conditions are much more complex, for, as you may know, the typhoid germ has been confounded with ordinary fecal bacteria for some years past. The frequent announcements of the detection of typhoid bacilli in water are now generally regarded as false alarms. However, the non-discovery of typhoid bacilli does not mean their non-existence. Until satisfactory processes have been worked out, the suspicion of typhoid infection must rest upon other facts than the detection of typhoid bacilli. Very recently a method has been suggested which may eventually solve the difficulty. It consists in adding a little potassium iodide to gelatine plates, by which the typhoid germs in fecal discharges are brought out without much difficulty. This method may be useful in determining typhoid bacilli in persons in whom typhoid might be suspected, but in whom definite symptoms are lacking and who are not very ill. One of the prominent workers on infectious diseases in Berlin (Brieger) has recently stated that the method has worked very well in making the diagnosis of typhoid in cases in which it

could not have been made clinically. We shall all look forward with interest to the more extended trial of this new method, especially in the recognition of mild attacks of typhoid fever, and in the persistence of these bacilli in the stools of convalescents and recovered cases. A knowledge of these things it quite essential in tracing the origin of epidemics and their relation to drinking water.

We may now approach the question how we shall determine the amount of pollution in water, leaving aside the presence of pathogenic bacteria. One of the methods which I have used for a number of years is to determine the number of colon bacilli, those bacilli which inhabit the intestinal tract of men and animals almost exclusively. It has been claimed that colon bacilli flourish outside of the intestines. It is true that they are widely distributed in nature, mainly because fecal discharges of human beings and animals are a common thing on the soil. The method which I have used consists in determining the presence of colon bacilli in water by their power of fermenting sugar. This test has been so satisfactory that I apply it whenever the opportunity presents. Large quantities of water may be used, a thing which is quite impossible with solid culture media, owing to the softening of the media.

But what is of especial importance is not simply to find the colon bacillus, for this may be found in almost any surface water, however pure, if enough water be taken for the examination, because animal life is everywhere. A bird passing across a stream may drop colon bacilli into the water. We know that they are present in the intestines of human beings, dogs, cats, sheep, cattle and swine. Hence the mere presence of the colon bacillis does not necessarily mean pollution with human excrement, nor does it mean that the water should not be used. What we do wish to find out is *how many* colon bacilli are in a given quantity of water, and I think if records of this sort were kept the increase or decrease in pollution might be traced week by week, month by month and year by year with a great deal of accuracy. Any sudden leakage of sewage into conduits or any injury to the latter might be discovered by such records. Prof. Jordan, of the Chicago University, found that the typhoid bacillus did not multiply in water, but the colon bacillus did. He tried water, however, from which he had eliminated all competitive bacteria, so that the question still remains, Will the colon bacillus multiply in ordinary water, which is already occupied

by a large number of water bacteria? If it multiplies abundantly, it would to a certain degree vitiate the test I have described. I am inclined to believe until proof to the contrary is forthcoming that colon bacilli do not multiply to any extent in water under natural conditions. The numerical estimate of *bacillus coli* in wells, it seems to me, would also be of great importance as denoting pollution, especially in country districts where the water is used in connection with dairies.

I wish to say a concluding word in regard to preventive measures. What can be done in case a water supply is infected? In regard to wells the problem is not so difficult. A number of years ago some German investigators tried lime, and found that to be fairly effective. They also tried a mixture of carbolic and sulphuric acid, and found that would sterilize a well; but these are very objectionable substances. More recently from the same quarter there has been suggested a method of injecting steam under a pressure of two atmospheres. This is forced into the water till the temperature is brought up to nearly the boiling point. The hot water destroys pathogenic organisms and, as it were, sterilizes the well. In reservoirs this treatment is not feasible. In such cases those using the water should boil it for a certain length of time. This is the safest method since pathogenic bacteria perish in water probably after two or three months at the longest.

In conclusion I wish to urge upon you the significance of mild cases of typhoid in starting infections, and the necessity for keeping a record of the numbers of bacteria and of the relative frequency of the colon bacillus in our water supplies. These suggestions are not so easily carried out, for they require more or less expenditure of money, but we must follow European nations in this respect, who are now conducting the regular biological examination of drinking water in nearly all large cities.

DISCUSSION.

THE PRESIDENT. This is a subject, gentlemen, in which we are all interested, and I think I simply voice the feeling of all the members of the Association when I assure Dr. Smith that his effort today has not fallen on barren ground, and that his paper will be read by a very much larger audience than is present here this afternoon. The subject is now open for discussion. I see a number here who

are interested in this matter directly, and I hope that they will have something to say. I will call on Prof. Sedgwick to add a few words on this subject; it is a matter he has had very much at heart I know for a great many years.

PROF. SEDGWICK. If I had had bacteria at heart for a great many years I suppose I should not be here now. Dr. Smith has told us that they are generally in the alimentary canal, which is perhaps the better place to keep them. I was sorry that our president did not get a chance to tell the Association in a few words just who and what Dr. Smith is, because I think when a new expert comes into our neighborhood and becomes, as I trust Dr. Smith may, one of us, we all want to know who he is; and if he will allow me to say a word or two about him, I think perhaps it will interest the Association quite as much as if I said anything on the subject upon which he has spoken.

Dr. Smith, after having graduated at Cornell University, and, if I am right, at the Albany Medical College, went into the employ of the United States government and became the head of the department of pathology, in the Bureau of Animal Industry. That is to say, it became his duty to follow up the diseases that come under the cognizance of the Department of Agriculture. This gave him very unusual opportunities to study the diseases of the lower animals, the diseases of swine, poultry, and so on, in all of which he has done magnificent work, and his papers are rightly regarded as of the very first importance on all these subjects.

Now, when the diphtheria scare, I won't say scare, when the diphtheria *science* I ought rather to call it, began to grow up within the last two or three years, the State Board of Health of Massachusetts saw that not only diphtheria, which was possibly transmitted through the lower animals, but also that many other diseases, such as malaria, possibly even typhoid fever, and some other things of which we have as yet comparatively little knowledge, were likely to become important, and that it was its duty in promoting the health and welfare of the citizens to have the very best knowledge upon all these subjects it was possible to obtain, it undertook to persuade Dr. Smith to leave his important position in Washington and become attached to the Board. And it is with very great pleasure to all workers connected with the Board, and to all citizens of the state who know anything about it, that Dr. Smith has finally con-

sented to come, has become connected also with Harvard College, and is now established in the laboratory belonging to the State Board of Health in the Bussey Institution of Harvard University out at Forest Hills.

Just at the moment, Dr. Smith is, I believe, working mostly upon the diphtheria anti-toxine, because it is highly important to have that in the right hands. But he is also ready, as occasion may demand his services, to take up the study of the origin, transmission, etc. of malaria; in fact he has already begun this investigation; he is ready at any time to devote his attention to an epidemic of cholera if it should come among us; he is ready to take up typhoid fever and find its ways and means among our people. In fact he is an expert employed now by the State Board of Health to look after the more intricate problems of the germ diseases as they may occur in this commonwealth. By virtue of the training and the work which he has had and done, we as citizens, those of us at least who are citizens of Massachusetts, and I think we may say all New Englanders too, (for knowledge and help of this kind radiates all through New England,) may congratulate ourselves that he has come among us.

The paper which he has given seems to me to require no comment. Any one who is familiar with the subject can see that it is written from a most thorough and intimate scientific and practical acquaintance with the subject with which he has had to deal; and I will not take your time by endeavoring to fasten more strongly the points which he has made. We can all heartily agree with them, and it seems to me we ought at this time especially to welcome Dr. Smith as an ally. If any man here having in charge a water supply finds some obscure disease charged by the citizens as coming from that water supply, he will find in Dr. Smith a strong arm working for his defense. I sincerely trust that we shall not be long in asking Dr. Smith to become a member of this Association.

I can also testify on my own part for Dr. Smith's information that he will find in this Association the men who practically oversee and manage the water supplies of New England; a body of men thoroughly practical and ready with every possible accomplishment that skill and engineering can supply. I have often been deeply impressed with the readiness and ability of the superintendents of the water works of New England. They are men also, as I think Dr. Smith will be glad to know, who are entirely ready and willing to

take up, as soon as it is established on any well thought out and well substantiated facts, any plan to prevent the spread of infectious diseases. We want in New England to have the best possible water supplies, and we are getting them little by little. I have always found the members of this Association most ready and eager to support the sanitary authorities in any judicious and right-minded measure. I think the Association should be congratulated on having heard Dr. Smith, and I think Dr. Smith is also to be congratulated on having met the Association.

THE PRESIDENT. I think we all subscribe to what Prof. Sedgwick has said, and that you are to be congratulated on the fact that I did not attempt to do what he has so much better done, and with a so much more intimate acquaintance with the subject. The paper is now open to you, gentlemen, for still further discussion, and I hope if there are any points which are not perfectly clear in Dr. Smith's paper you will ask him questions to bring them out. I would like to hear from Mr. Whipple, who has had charge of the laboratory for the Boston water works, and if Mr. Whipple says anything on this subject I hope he will give a statement of the number of bacteria ordinarily found in Boston water, which I think is very low, and which Dr. Smith will be gratified to learn.

Mr. WHIPPLE. In regard to the bacteriological work which has been done for the Boston water works, I may say that for the past three or four years we have made regularly, once each week, a bacteriological examination of the water in the reservoirs and in the various gate-houses on its way to the city, and the averages of these results by months are as follows:

BACTERIA IN BOSTON WATER.

Number per cubic centimeter.

Average of weekly analyses for four years (1892–1895 inclusive), samples collected from a tap in Park Sq.

Jan	135	July	73
Feb	211	Aug	81
Mar	102	Sept	86
Apr	52	Oct	55
May	53	Nov	56
June	86	Dec	52
	Mean	87	

I would also say that for the past two or three years we have been using Dr. Smith's method of the fermentation tube in identifying the bacillus coli communis, and we have found it to be a very successful one.

DR. SMITH. It may be of interest to the members to compare the numbers of bacteria as mentioned by Mr. Whipple with those in the Potomac water used in Washington. In the winter, when the water is very turbid, the numbers rise from 1,000 to 8,000; in the summer, when it is very clear, the numbers fall to 100 or 150, and fluctuate between those two extremes.

THE PRESIDENT. I should like to ask Dr. Smith if it has not been found that the crews of some vessels which go from the Potomac to South America, for instance, have been seized with malaria where they have depended upon the local waters, and where they have taken a supply of water with them for the whole voyage they have not had malaria? I have heard that statement made, and it has been brought forward as an argument in favor of the theory that malaria is transmitted in water.

DR. SMITH. I do not recall any such instance. The history of medicine for the last fifty years, however, is full of similar illustrations, but a good many of them don't hold water. (Laughter.)

PROF. SEDGWICK. Mr. President, there was one thing brought out by Dr. Smith which I think we ought always to keep in mind, and that is with regard to the explanation to give to people when they say: "Why, I have drunk this water for the last ten years, and you see how much I weigh," and when they add to that: "and not only so, but my father drank it, and lived to be ninety-nine and my grandfather reached a fine old age," and so on. Now, the answer I always give to these people, and it is one which I think very useful, is that "that is all right," and then I say: "Look here, did you ever see a Grand Army procession?" They say: "Yes." "Well," I say, "they look pretty healthy." "Yes, they are remarkably healthy—about pension time, especially." "Well, then, war isn't a bad thing, judging by these people. I saw them march here in Boston two or three years ago, and as they went down the street they were a magnificent set of men, splendid; and as I looked at them I thought war isn't such a very bad thing after all." Now, the point is the same in both cases. These are the survivors. We don't see those who

are lying in the graveyards hereabouts, or at Arlington or elsewhere; and because you and I and a half dozen others have been tough enough, and our ancestors, perhaps, also have been tough enough to withstand all these things, it doesn't follow that a lot of other people haven't died of them. So it is well to remember the Grand Army when we are thinking of these things, and not to judge of war by the survivors. If you are going to judge of the effects of war, you must judge by the numbers killed, and they are not generally on hand to be counted.

If I found anything at all to, I won't say criticise, but to wonder at a little in Dr. Smith's paper, it would be his feeling that all sewage contains the germs of typhoid. Perhaps I am stating it too strongly, but that was the idea, at any rate, that if sewage runs into a stream, say for one day or for one week, from a city, it must contain typhoid. It seems to me that there is a little danger in that argument, that it might prove almost too much, because there are times when cities have drunk sewage-polluted water for a considerable time without any appreciable amount of typhoid. And I don't think I can go quite as far as Dr. Smith does in that matter. There were times under the old regime, before their water works were improved, when Lowell and Lawrence used to drink very straight sewage-polluted water, and yet there were such times when they had very little typhoid fever. And those times curiously enough, were generally in midsummer, In fact it was the case all along that river that we got the worst typhoid after a freshet, when the amount of sewage as such in the water was relatively small, the amount of rain water being relatively large. So it seems to me if we don't look out, Dr. Smith's argument will prove a little too much.

But it seems to me that in the main Dr. Smith's point is perfectly sound. We want to avoid the appearance of evil, of course, here as in other things. We don't want sewage polluted water, and it is a fact, and a fact of which I think this Association has great reason to be proud, that in New England the water works are being put into most excellent shape. Lowell and Lawrence were, perhaps, the worst sinners, but they are both of them on the road towards good water supplies and it is a matter for very great congratulation.

With regard to the Boston water, the numbers of bacteria we find at the tap at the Institute are often a little higher than those Mr. Whipple gives, but we are not frightened by moderate

numbers. I was very glad indeed to hear Dr. Smith take the ground he did in regard to the numerical estimate. About all that means, of course, is the relative cleanness of the water. But even that is a great deal, and it seems to me his ideas on that are exceedingly sound. All these latter points for the determination of the species are invaluable to the biologist. We can hardly expect that the ordinary New England water works superintendent will follow that very closely or care very much about it. He looks to the bacteriologist for results, and he will apply them when he needs to do so.

I was particularly grateful to hear Dr. Smith say so much about personal infection. I was laughed at a good deal when I brought up some reports to the State Board of Health proving that certain epidemics of typhoid were due to secondary infection, as I called it, that is, by actual filth conveyed from person to person. Having found that the wells were not bad and the water supply was good, I finally hunted it down and found it had gone in a sneaking, round-about way from person to person. I felt it almost a duty to say it was water or milk, but the facts were the other way; and it is true undoubtedly, that some epidemics have been charged to water and wells when the wells have'nt had anything whatever to do with them. And there again it seems to me Dr. Smith hit the nail on the head. There are not many men in this country, let me tell you, who are ready to take the ground that Dr. Smith has taken, and which I believe firmly to be true, that the trouble with wells comes in as a rule from the top and not from the ground. If at Lawrence five feet of sand can remove all the disease germs, how in the world are they going to get through, except in the rarest cases, into the bottoms of wells from adjoining sources of pollution? I ventured to say this at Chicago before the American Public Health Association, and some of the wiseacres there who have been talking about wells and the dangers from wells for years, laughed me to scorn and were really quite angry about it. It is an old idea, you know, that if you have a cesspool up here and a well a little lower down, you can easily draw on a blackboard a figure showing how the filth from a cesspool finds its way down to the bottom of a well perhaps 50 or 20 feet away. Now perhaps it does; in some cases I believe it does, but it is a significant fact that all the time we have been studying typhoid here in Massachusetts for five years, and studying it hard, we have

never found more than one or two cases in which we even strongly suspected a well. The fact is, as Dr. Smith says, and I believe it implicitly, that whenever you get an infected well, the infection comes in at the top. You may get of course the seepage from a cesspool or anything of that kind, but in nearly every case it is well filtered and well purified on the way. When you get infection in a well I believe you get it in at the top. I have believed it for several years and have been criticised for believing it, and I welcome Dr. Smith's statement therefore as a most happy substantiation of those ideas of my own. We must look at facts rather than merely at books, and we must not generalize from one case. It seems to me Dr. Smith has done us a very great service in putting the matter as clearly as he has this afternoon.

MR. NOYES. It has occurred to me that possibly Prof. Sedgwick has made his last statement somewhat more broadly than the facts would warrant—that is, when applied to all wells under all conditions. I suppose he means a well that is sunk in a drift material, or a material through which water has to pass very slowly, and where the material acts as a filter. There are other cases where water reaches the well from distant points through fissures in the rocks or by other channels to which this would not apply, and it seems to me it is proper to put that on record as qualifying his statement rather than to have it misjudged by persons casually reading the report of this meeting.

PROF. SEDGWICK. I am much obliged to Mr. Noyes. Of course that is perfectly true, and that is exactly what I meant. Where there is an open connection from cesspool to well it is like going in from the top, of course.

MR. THOMAS. As bearing out what Prof. Sedgwick said in regard to Lowell, the agent of the Lowell Board of Health informed me the other day that the amount of typhoid fever in Lowell would be about 50 per cent. less during the year 1895 than it was in previous years. He also informed me that during the month of August there was not a single case of typhoid fever reported in Lowell.

DR. SMITH. I would like to say a few words in regard to the suggestion made by Prof. Sedgwick. I think it is perfectly true that my statement was a little overdrawn. What I intended to say was that we should act as if all sewage-polluted water contained typhoid germs. We should not let any sewage-polluted water go into the

intestines of people without doing something to it. Furthermore, in large communities there are always some cases of typhoid, and hence always a few typhoid bacilli in the sewage from such communities. We have still a great deal to learn concerning the passage of the typhoid fever bacilli into the intestines and the subsequent outbreak of the disease. I trust that the method which has just been suggested in Germany will help us to diagnose mild cases of typhoid, and I hope it will also enable us to demonstrate the presence of typhoid fever bacilli in sewage-polluted water. Another fact to be taken into consideration is this, that typhoid is not a very mortal disease. Only about 12 per cent. of the people who have typhoid die. How many more may swallow the germs without contracting the disease at all, we do not know, but I trust that we shall some time.

In regard to direct infection I would say that Brieger has described in his article several cases of nurses in whose stools the germs were found. This certainly points to direct infection from patient to nurse.

MR. RICHARDS. We have heard very much about sewage contamination, and I now would like to ask Dr. Smith if it is proven that water is contaminated in any other way; for instance, whether swamp water communicates disease, or if there is any disease carried in water but that which is conveyed through sewage contamination.

DR. SMITH. I think what I said about malaria would cover that question pretty thoroughly, because malaria has generally been considered as being transmitted by swamp water and not by sewage-polluted water. On this subject we know nothing positive. The known diseases which I have described, except possibly malaria, can come in no other way excepting from another person indirectly or directly, and consequently swamp water must be first infected by the germs of the specific disease. But there may possibly be forms of dysentery or of diarrhœa which are due to water bacteria and such bacteria as live only in swamps.

MR. RICHARDS. That is not proven?

DR. SMITH. I know nothing definite about that subject, and I think there is nothing on record.

THE PRESIDENT. I should like to say it is not only from wells we are likely to get direct sewage contamination in our water supplies, for in the course of my own examinations I have seen sewage coming

directly into water supplied to cities and towns in tunnels and in other places, through fissures in the rocks, as Mr. Noyes has suggested, in places that are almost unknown to the authorities. This is a subject I hope to have something to say about at some future time more in detail. I think it is a matter which has never been very much discussed, but I believe it to be worthy of very careful consideration. We should build our aqueducts and tunnels which are constructed to carry pure water to a city, in such a manner that the soil water cannot enter them, at any rate where there is danger of sewage contamination.

MR. COGGESHALL. It is a popular belief, (I don't know that there are any facts to substantiate the truth of it,) that years ago malaria was an unknown disease in the New England states; that at first it made its appearance in the western part, and then spread rapidly in the Connecticut valley, and finally traveled on until it appeared in Providence and many of the eastern cities. Now, has any theory ever been presented in regard to that which would explain it?

DR. SMITH. I regret to say that all that is known of malaria now is that it is due to certain organisms living in the blood; anything beyond this is all conjecture, but we hope to take up this question and do as much as we can towards solving it, if that is ever possible. It is a very obscure question at the best owing to the nature of the organisms which produce the disease.

PROF. SEDGWICK. Has the malaria germ ever been found outside the body?

DR. SMITH. Some Italian observers have described it, but I think the statement is not at all reliable.

MR. COGGESHALL. Can you tell me whether it is as apt to occur in a salt marsh as in a fresh water swamp?

DR. SMITH. I am unable to answer that question directly. I believe the most dangerous marshes are those that have brackish water, where fresh water mingles with the salt water and the salt water with the fresh water. I think that is a statement current in the books.

MR. CHASE. The last annual report of the State Board of Health of North Carolina contains a very elaborate paper by Dr. Lewis, secretary of the board, on the relation of drinking water to malaria. He has made an extensive investigation and considers he has demonstrated the connection of malaria with drinking water, and he

bases it largely upon the fact that in the eastern portion of the state, where heretofore they have been dependent upon shallow wells or small streams, but where they have now introduced the use of deep artesian wells, malaria has disappeared. And investigations of my own in certain localities have given me that idea. At the same time I have been confronted with the fact that a party of young men who went to a village in the eastern portion of the state, and who were so very much afraid of having malaria that they would not trust the local waters at all, or even rain water, but confined themselves to apollinaris, had malaria worse than any other people living in the locality.

THE PRESIDENT. I understood Dr. Smith to state that there was no theory to account for the prevalence of typhoid fever in September. But following out your statement as to the pathogenic germs in water, why is it not possible that the low flow of the streams in September concentrates the number of germs to such an extent that that might account for the increase in the disease? You know that the streams are very much lower at that time of the year than at any other time.

DR. SMITH. That is true, but the evidence we have is complicated by the great movement of people between the city and country at that season of the year. In the country, wells are largely in use.

THE PRESIDENT. Might not the amount of water in the wells have been very much smaller at that time, and the dilution very much less?

DR. SMITH. Undoubtedly concentration plays a part in it, but the further the ground water is below the surface the less it would seem likely to become polluted.

A MEMBER. I would like to ask one question. You spoke of a boy who fell into the river and the next day was taken down with cholera. Now, I have heard the question asked a good many times as to whether a single glass of milk or a single glass of water containing typhoid fever germs was sufficient to produce the disease. In connection with this fact of the water being filtered in a well, and therefore the number of organisms being small, I would like to ask Dr. Smith if he considers it is necessary to drink typhoid contaminated water on a number of different occasions, or whether a single dose would probably be sufficient to produce the disease.

DR. SMITH. That is a very difficult question to answer. Experimentally we know that the smaller the number of germs we inject under the skin of a rabbit or guinea pig, the less likely it is to cause the disease in the animal. With some bacteria we can reduce it to a point where no disease will appear, and the system will get the better of the germs. As we increase the number, the more likely we are to produce the disease, and at a certain point it is always produced. One germ which is taken in a glass of water may be destroyed, another in the next glass may be destroyed, and in the third glass there may be five or six, and these may begin to multiply and start the disease. Of course it is possible that the disease if it appears at all may come from a single germ. It is a very difficult question to settle in any way except by experiment. It should always be borne in mind that the receptivity of the individual varies from time to time.

On motion of Mr. Noyes a vote of thanks was given to Dr. Smith for his valuable and interesting paper.

DESCRIPTION OF SECOND TUBE WELL PLANT AT LOWELL, MASS.

BY

GEO. BOWERS, CITY ENGINEER, LOWELL, MASS.

[Read Feb. 12, 1896.]

On June 14th, 1894, I read a paper before this Association which included a description of our first tube well plant, "The Cook Wells." In August of that year a contract was made by the city of Lowell with the Hydraulic Construction Company of New York, for a plant of tube wells of sufficient capacity to furnish and deliver into the city mains 2,000,000 gallons of water each and every day of twenty-four hours. The contract stated that these wells should be located in the same valley with the Cook wells, and should not deplete or take water from them. To select a location that would fulfill the requirements of this contract was a difficult piece of work, requiring the testing of the ground for a mile and a half up the stream southerly from the Cook plant. To do this thoroughly seventy test wells were put down. The place selected was about one mile south of the Cook plant on the northerly side of River Meadow brook.

The first permanent work done was the construction of what is now known as Section A. January 3rd, 1895, this section contained forty-two 2-inch wells, 45 feet deep, placed on each side of a 12-inch suction main, 25 feet apart and 6 feet from the suction main. The connections were at an angle of forty-five degrees with the main, and the wells made with perforated brass screens. A test of these wells was made from January 10th to 27th, the actual time of test being sixteen days, eleven hours, twenty-three minutes, and

the quantity of water pumped 29,972,597 gallons by meter measurement; during the test the ground water was lowered about ten and one-half feet. All the temporary tests at this plant were made with a fifty horse power engine and an 8-inch centrifugal pump.

Another section (now known as Section B) consisting of seventeen wells was then built and tested by pumping six days, five hours, thirty-four minutes, the quantity pumped being 5,283,599 gallons. During these tests the suction main was near the surface of the ground but was afterwards lowered about five feet.

On account of the large amount of water in the ground (it reaching nearly to the surface), it appeared to be a very difficult piece of work to lower the main, excavate for the pit and build the foundation for the permanent pumps; but by making use of the wells already driven to lower the ground water, this difficulty was, in a large measure, overcome.

A large cast-iron receiver was first set in place, then Section A was pumped while Section B was being lowered, the pit excavated, the permanent pumps set in place and twenty-three more new wells added, making forty wells in Section B. The permanent pumps were now started and the wells of Section B pumped while the suction main of Section A was in its turn lowered. While this was being done 2,300,000 gallons of water were daily pumped into the city mains. On June 6th, the construction of Section C was begun. This, the third section, was laid out at right angles to the other two sections and was finished October 7th, although a portion of this line was in use long before the whole was completed. In building this section a very deep deposit of soil was found, extending for a distance of about three hundred feet and varying from six to thirty-five feet in depth. No wells were driven in this place and the suction main was supported by piles. Every twelve-foot length of pipe was supported by four piles driven through the soil into the sand or gravel below; this work necessitated more time than would otherwise have been required for building this section. The plant now consists of 120 wells connected by 1,519 feet of 12-inch suction pipe. The pumping is done by two Worthington pumps each capable of pumping 3,000,000 gallons of water daily.

From April 5th, 1895, to February 1st, 1896, 921,063,299 gallons of water were pumped and measured by a Venturi meter. The amount pumped each month was as follows:

PUMPAGE AT THE HYDRAULIC CONSTRUCTION COMPANY'S WELLS.

1895.

Month.	Gallons.	Remarks.
April	71,516,074	Commenced pumping April 5, 1895.
May	76,529,295	
June	70,107,764	
July	92,862,888	
August	95,203,073	
September	88,455,627	
October	102,212,358	
November	106,443,065	
December	110,746,609	
January, 1896	106,986,546	
Total	921,063,299	

Average quantity pumped per day, 3,049,878 gallons.

This plant has never been pumped to its limit, the contract requiring not less than two, nor more than three million gallons to be pumped each and every day. The contractor has pumped, except during a break in the suction main in September, just a little over three million gallons per day.

During the great rainfall of November the valley became flooded and soon greatly increased the amount of water in the wells. Iron and lime were found in the water from Section A at this time which necessitated the closing of those wells; this, however, is only a temporary trouble.

I wish to call your attention particularly to this method of pumping the water when construction is being carried on in wet places. If the right kind of well is used and properly sunk, so as to intercept the water, the pressure of the ground water will be taken care of. If the excavation is in sand or gravel this will be all that is needed; but if there should be a stratum of clay or impervious material which prevents the water getting to the wells, this surface water would have to be pumped also. I recently used an ejector for the surface water with very good results. By this method the place excavated is left in an excellent condition for building.

DISCUSSION.

In reply to a question from the President, Mr. Bowers stated that a 20-inch Venturi meter was used for measuring water. It was being watched very carefully, and is believed to be recording the quantity of water accurately, probably within two per cent. It is placed back of the pumps so that any air drawn from the wells has been removed from the water before it reaches the meter and no disturbance can be produced in this way. The quantities given were determined with this meter. The hardness of the water at the present time is about 4.0 degrees; it has been as high as 7.0 and 8.0.

In reply to a question from Mr. Holden he stated that the wells were from 45 to 50 feet deep, and that although there was more water in the wells two or three weeks after a rain than at other times, he did not think that any brook water found its way into the wells without being adequately purified.

Mr. Rice stated that he had been much interested in what Mr. Bowers had said, and had followed his investigations with a good deal of interest, because he had been an assistant of Mr. Davis in 1870 when the original works were built. He stated that at that time Mr. Davis thought that the best system would be to have settling basins along the Merrimac river. The filter gallery was not an idea of Mr. Davis, who built it only on the explicit order of the Water Board or city Council; and he wanted to call attention to the method of filtration in use at Lawrence as the proper system for supplying such a city, and as better than the driven wells. Mr. Rice further stated that with the tendency towards hardness and iron there must be an end to using the driven well water in Lowell, and he understood that the city hall had cut off its water supply and was now using water supplied by the Merrimac Corporation.

Mr. Bowers in reply stated that the man who takes care of some of the boilers in the city hall did not take proper care of them, and as a result had had some trouble and had recently changed from city water to the river water, but in other cases where boilers were properly taken care of no trouble had been experienced with the driven well water. He did not consider the hardness of the well water as excessive, and it was apparently not increasing, for the analysis had not changed during the past year.

HANDLING FIRES WHILE CHANGING DISTRIBUTION MAINS UPON IMPORTANT STREETS.

BY

GEO. F. CHACE, Superintendent Taunton Water Works.

[Read Feb. 12th, 1896.]

Taunton has that method of water supply held in such low esteem by New England engineers, namely, the Holly System of Direct Pumping.

When the works were first built, in 1876, there was only one principal force main from the pumping station to the city, 20 inches in diameter, 1.3 miles long, and feeding a 16-inch main, 1,690 feet long, which runs through Main street.

In 1880, a second force main was laid from the pumping station over another route. This line consisted of 1,300 feet of 12-inch, and 1,900 feet of 10-inch pipe which joined an 8-inch pipe, 1,451 feet long, which was connected with the 16-inch pipe running through Main street.

In 1894, the above 8 and 10-inch mains were replaced by 20-inch. During the past year about 5½ miles of 12, 10, 8, 6, and 4-inch mains have been replaced by 20, 16, 12, and 8-inch pipes. This work involved changes through some of the principal business thoroughfares and included the completion of a second 20-inch system from the pumping station, giving the city now a duplicate 20-inch supply.

As Taunton now has a population, according to the census of 1895, of 27,093 and uses only 43 gallons per inhabitant per day, either one of these mains is sufficient to supply the city for a long time to come.

The work of replacement this year began in April and continued without interruption until October and was not entirely finished until the middle of November.

The changes were carried on simultaneously in two parts of the city, in one by a contractor, and in the other by the water department.

During this period the traffic of the streets was not seriously interrupted, the domestic supply did not fail upon any street, and an adequate fire pressure was not wanting at any one of 31 fires.

Some of you will remember that a few years ago a large part of the business portion of an important town in Worcester county was destroyed by fire, because the latter occurred at a time when the supply from the reservoir was interrupted for repairs upon the force main, which was the sole reliance for connecting the reservoir with the distribution mains of the town.

The same kind of disaster would undoubtedly have occurred in Taunton last spring if the city had not possessed more than one line from the pumping station.

As I have been asked to give a short experience paper, the experience of the Taunton Water Department in handling the most dangerous fire of the past season, while distribution changes were going on, may be of interest, and one example may serve for all.

On May 31, at 2.49 p. m., there was an alarm for a fire in the rear of Union Block. This is a three-story brick building on the corner of Main and Weir streets in the business heart of the city. The fire started among some old rags which had been used in polishing furniture and which were lying in a small wooden annex belonging to a furniture and crockery store in the brick block. This block in the rear was four stories high, with an attic, having a window in the gable, facing the rear alley way. The flames very quickly mounted into the upper story and attic, as well as into the store room on the lower floor of the brick structure.

In the rear of Union Block is a dangerous fire trap of old wooden stables, dwellings, planing mills, saw mills, and lumber yards.

A few minutes before the fire alarm sounded I had started, in company with a building contractor, who had been doing some work for us, to visit our Lakeville pumping station. I told him I must wait and see what the fire was, before I thought it would be prudent to leave town.

There is a private alley leading from Main street to the rear of Union Block, and another leading from Weir street to the same point. Opposite the alley way on Weir street is a 4-way Chapman hydrant. On Main street, about 50 feet from the head of the alley leading from this street, is another 4-way Chapman hydrant. There is a 16-inch pipe on Main street and an 8-inch on Weir street. Within a few feet of the burning building was a 2-way hydrant at the end of about 200 feet of 4-inch pipe, leading out of the 8-inch on Weir street.

When I reached the scene, which was within ten minutes of the alarm, the fire department had four hose lines laid from the Main street 4-way, three lines from the 4-way on Weir street, and one from the small hydrant in the rear. Some of these lines had already begun to throw streams. In a few minutes they were all playing.

But for a while the fire appeared to be having its own way. It had run up into the attic where there was no chance to reach it in that quarter except through the gable window already noticed. The fire department had a Hayes' truck aerial ladder, to use as a water tower; but, being cramped for room, the firemen had some difficulty in getting this apparatus into an effective position. Meantime, the flames began to break through the roof. It was a hot day, the thermometer reaching 88° F. at noon, and the domestic consumption was large. Fearing the number of hose streams would soon have to be doubled, I hurried to the office telephone and ordered the second engine started, as a precaution. I was gone from the scene of the fire about ten or twelve minutes. On my return I found the Hayes' truck and ladder was in position and a powerful stream from a nozzle on a level with the gable window was playing directly into the heart of the attic fire, and the threatened conflagration appeared to be under control.

At 4.10 p. m. the fire was out and the recall sounded. In one hour and twenty-one minutes a very threatening fire, in the business center, in the midst of a perfect tinder-box of combustible material, had been completely squelched. The blaze did not get through the door of the store room into the main store filled with valuable crockery. A lounge in the attic for repairs, although somewhat drenched, was not even scorched. Some pictures of footlight favorites on the attic walls were still hanging in all their tawdry glory.

The amount of risk and loss will be understood from the following

figures furnished by courtesy of the chief engineer of the fire department.

Value of building	$6,500
Insurance on building	4,000
Loss on building	1,025
Insurance paid	725
Value of contents of building	3,200
Insurance	2,750
Loss	1,750
Insurance paid	1,750
Loss to the insurance companies on $9,700 was	$2,475
Loss to the owners	300

The latter was on the wooden structure which was uninsured.

A failure in the pressure at the critical period of this fire would have been disastrous. The surroundings were very combustible and there were other valuable stocks in Union Block in addition to the property contained in the furniture store.

The men of the water department had strict orders to keep everything heavily braced where there was a chance to blow out temporary plugs on unfinished work, and these orders were faithfully obeyed.

Although one force main from the pumping station was out of commission, because of the change in progress from 12-inch to 20-inch pipe, the other 20-inch main kept up the supply.

If more streams had been needed, there were four additional 4-way hydrants within 500 feet of the spot where the fire started.

DISCUSSION.

In reply to questions from the President and others Mr. Chace stated that there was no reservoir in Taunton, but that a pressure of 100 pounds was maintained at the engines; and while he did not know the exact pressure on the hydrants, there were usually 90 pounds shown on the gauge at the office, and that with 15 fire streams in use at once there had been 64 or 65 pounds pressure, and with 12 streams 70 pounds had been noted. He also stated that only one engine was kept in reserve but that was ready to start at any time and that a full supply could be obtained within one or two minutes.

In reply to a question from Mr. Haskell he stated that he should be glad to have a standpipe, but that the city was not altogether dependent upon the engines, for the water is received by gravity under a pressure of 28 pounds.

THE FRICTION IN SEVERAL PUMPING MAINS.

BY

FREEMAN C. COFFIN, C. E., Boston, Mass.

[Read Feb. 12, 1896.]

I have recently had opportunities to experiment upon several pumping mains, and in a practical manner to determine the friction caused by the flow of water at different velocities, and to compare the results with the formulæ in use.

The velocity or quantity of water was obtained from the revolutions of the pump, with a proper allowance for slip in each case. The friction head was measured by the difference of the static and dynamic head as shown on the pressure gauges connected with the main. I believe that there was no error from the readings of the pressure gauges to exceed one foot, and in most cases the errors were much less, as the gauges were graduated to a large scale. It was my endeavor to have all such errors, if any, on the safe side, or on that of increased friction. The gauges were so nearly accurate that there would be no appreciable error in the range covering the increase of pressure due to friction.

The static head was observed before the pumps were started, and, in cases where the water was pumped into a standpipe, account was taken of the rise of water or increase in static head.

The observations of the pumps were carefully made, both as to revolutions per minute and length of stroke, and although the extreme accuracy of carefully made hydraulic experiments was not possible, I believe that substantial accuracy sufficient for practical purposes was obtained. The fact that the mains were long, tended to reduce the proportional error due to errors of observation.

IPSWICH MAIN.

This was a compound main consisting of 9,060 feet of 12-inch pipe with no bends except those of long radius, no side outlets and perhaps half a dozen house services; 1,000 feet of 12-inch pipe continuing from the first one, but with an 8-inch side outlet at its junction with the first portion and a 6-inch side outlet at about one-half of its length. These pipes passed into a system in

such a manner that I estimate that one-half the flow passes through the 1,000 feet of 12-inch pipe; but it must be admitted that there is an element of uncertainty in this part of the line. However, it would make but little difference in the total result whether one-fourth, one-half or three-fourths of the water passes through this short length, as the total computed friction through it is very small as shown by the seventh column in Table A.

The remainder of the line to the reservoir was 1,150 feet of 14-inch pipe without branch or service. The total flow from the pump with the exception of the ordinary consumption, passes through this line into the reservoir. The total daily consumption was 40,000 gallons; assuming that seventy-five per cent. of this was used in the twelve day hours, then the average day hour consumption was forty-two gallons per minute, which was the amount deducted from the total to get the amount flowing through the 14-inch pipe. There was one right-angled bend made by a globe special at the junction of the 12 and 14-inch lines, as well as several gates and globe special hydrant branches on the lines and also two check valves.

In Table A are given the results of these experiments and a comparison of the actual friction with that computed by means of the Chezy formula $V=C(rs)^{\frac{1}{2}}$ or $s \frac{v^2}{c^2 r}$ using for the coefficient c the values given by Hamilton Smith, Jr., as estimated from his diagram for the different sizes of pipes as closely as possible. These values are given on diagram No. 2.

WALPOLE MAIN.

This is a compound main consisting of 6,950 feet of 12-inch pipe and 8,900 feet of 10-inch pipe. At the time of the test there was no consumption and no side mains open to complicate matters. There were four right angle bends made with globe specials and six long bends, many hydrants and other branches and gates upon the line. The water was pumped into a stand-pipe. The static pressure was observed before the pump was started and after it was stopped at the end of the experiments. The static head for each experiment was estimated in proportion to the amount of water pumped into the stand-pipe at the time the experiment was made. The total rise in the stand-pipe was 4½ feet. The slip was taken as 2.5 per cent. The results of these experiments are given in Table B.

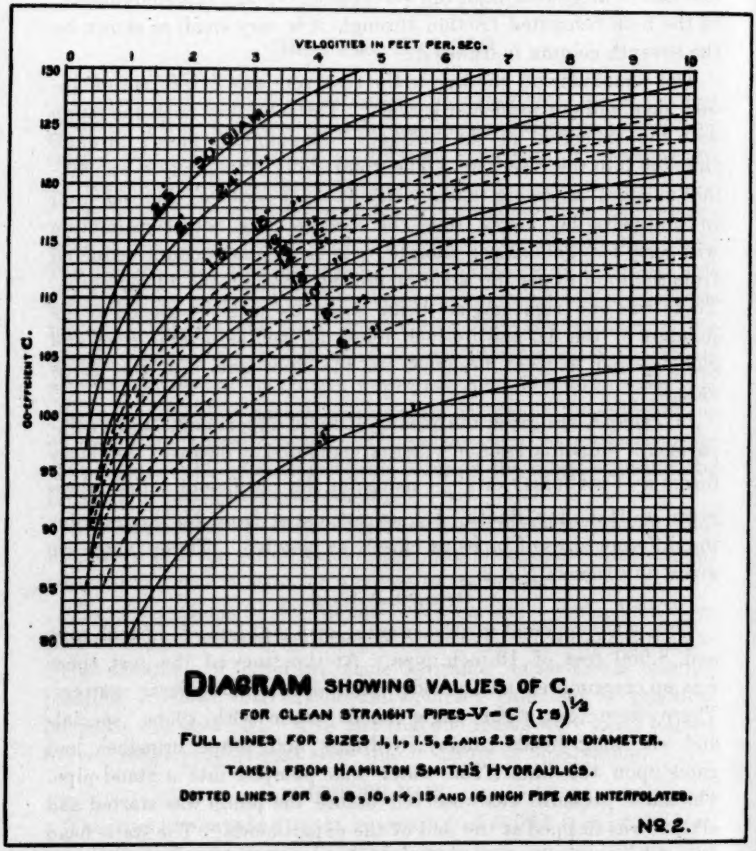

DIAGRAM SHOWING VALUES OF C.

FOR CLEAN STRAIGHT PIPES-$V = C\,(rs)^{1/2}$

FULL LINES FOR SIZES .1, 1., 1.5, 2. AND 2.5 FEET IN DIAMETER.

TAKEN FROM HAMILTON SMITH'S HYDRAULICS.

DOTTED LINES FOR 6, 8, 10, 14, 15 AND 16 INCH PIPE ARE INTERPOLATED.

NO. 2.

ATTLEBORO MAIN.

This is also a compound main consisting of 6,400 feet of 16-inch, 10,750 feet of 14-inch and 375 feet of 12-inch pipe. The 16-inch pipe which was nearest the pump was entirely free from open side outlets, as was also the 14-inch. The latter, however, supplied at its farthest end, that is the end nearest the stand-pipe, about 250 people; their draft during the hours of the observation would be ten or eleven gallons per minute, but being so near the end of the 14-inch pipe would not affect the results appreciably. The 12-inch pipe carried all the water pumped from the 14-inch pipe to the stand-pipe, except that used by the town, which is estimated at 400 gallons per minute, on the assumption that seventy-five per cent. of the consumption is between 6 a. m. and 6 p. m., and this amount was deducted in computing the friction in the 12-inch pipe.

The stand-pipe was provided with a gauge recording by electricity in the pumping station. The static head was read from this simultaneously with the dynamic head from the pressure gauge on the main. The slip was estimated at two per cent. There were three right angle bends and numerous branches and gates on the line. The results of these experiments are shown in Table C.

TAUNTON 30-INCH MAIN.

This is a simple main of 36,700 feet of 30-inch pipe. It is used as a suction or supply main for the pump which takes the water under a static head of sixty-six feet. These experiments were very satisfactory as far as they went, but the range of velocities was very low, namely from .47 to 1.15 feet per second, the velocity being limited by the safe speed of the pump. The slip of the pumps was estimated at five per cent. The results of these experiments are given in Table D.

TAUNTON 24-INCH MAIN.

This is a compound main composed of 6,000 feet of 24-inch pipe and 50 feet of 18-inch pipe. There are no branches or services upon it. The actual friction in this main exceeded the computed friction by a large percentage as shown in Table E.

SOUTH WALPOLE MAIN.

This was a compound main, consisting of 8,874 feet of 8-inch; 1,735 feet of 10-inch, and 197 feet of 12-inch pipe. The tests were made under practically the same conditions as those upon the Wal-

pole main. There was no consumption and complications of side mains. The water was all pumped directly into the stand pipe. The pipe was laid in 1895. The results are given in Table H.

I was surprised to find that the friction in the Ipswich line (the first one experimented upon) was less than the computed friction for clean, straight pipes. I expected that the gates and branches and two check-valves upon the line would cause considerable loss of head and make the actual friction head above that of the straight pipes as computed by the formula named. The experiments on the Walpole pipe show about the same results and seem to confirm the first.

The older pipe at Attleboro and the Taunton 30-inch line show slightly different results especially in the higher velocities, where the actual friction head is greater than the computed head, and the friction in the Taunton 24-inch line was still more in excess of the computed friction.

It may be that the increased frictions in the Attleboro and in Taunton 30-inch line are due to tuberculation or deterioration of the inner surfaces of the pipes, but this will not probably account for the greater increase in the 24-inch line, and I do not know of any condition that should cause this increase over the 30-inch or the Attleboro line.

The years in which the pipe lines were laid were as follows: Walpole, 1895; Ipswich, 1894; Taunton 24-inch main, 1893; Taunton 30-inch line, 1892, and Attleboro, 1892.

This result of greater friction in the older lines is interesting on account of the significance of the condition of the inner surface of the pipe lines and its influence upon their discharge, especially at this time, when so much interest has been aroused on the subject of the character of the inner surfaces of pipes by the recent developments in regard to the delivery of the riveted steel pipe line of the East Jersey Water Company. It is well known that the roughness of the pipe is an important element, but the degree to which it affects the delivery has not been determined, and it may be that enough consideration has not generally been given to it in designing pipe lines and systems.

Mr. Desmond FitzGerald, in a paper recently read before the American Society of Civil Engineers, shows that in a 48-inch coated cast iron pipe, the removal of the tuberculation of 18 years' growth,

caused an increase of 30 per cent. in the discharge of the pipe, which is equivalent to a reduction of about 23 per cent. in the discharge of clean pipes caused by that degree of tuberculation, or an increase of the frictional head of about 69 per cent.

This conclusively shows that the effect of tuberculation is no slight matter, and although it is not possible at present to accurately state the effect produced by any age or condition of pipe, the fact should be emphasized that it is necessary to allow a wide margin for the increase of friction, or in other words, the decrease in delivery, unless it is intended to clean the pipes, or lay future supplementary lines.

I consider that the results of the experiments described in this paper, indicate that it is safe, in the sizes experimented upon, to use the formula and coefficients mentioned for new pipe lines of coated cast iron, that they also indicate a reduction of the capacity of a pipe line with age, and that this reduction commences in a slight degree in a very few years.

GRAPHIC COMPARISON OF RESULTS.

Diagram No. 1 shows the results of these experiments plotted on Logarithmic cross section paper, and also the theoretical results in clean, straight pipes. The results of three different formulæ are shown in each case by as many different kinds of lines. The author is indebted to Mr. John R. Freeman for the 10-inch base Logarithmic paper upon which the diagram is made.

The actual results are shown by a heavy, full line. Those obtained by the Chezy formula with Smith's coefficient are shown by a light, full line. Those by a formula proposed by W. E. Foss by a light, broken line. This formula which is most convenient. It was proposed and its derivation described by Mr. W. E. Foss in a paper read before the Boston Society of Civil Engineers in 1894, and published in the *Journal of Associated Engineering Societies*, of June, 1894. The results of this formula nearly coincide with those of the Smith–Chezy formula, and it deserves especial mention on account of its extreme simplicity. According to Mr. Foss' nomenclature: $I = C^1 Q^{\frac{1}{6}}$ when I = friction head per foot, Q = discharge in cubic feet per second, and C^1 = a coefficient, a table of which he gives for different diameters. He also gives a table of $\frac{1}{6}$ powers.

The third formula is that of Darcy for clean, straight pipes. This

is represented by a light dotted line. The results of these three formulæ for these sizes of pipes and for ordinary velocities do not differ materially.

Besides the experiments described above, the results of a series of observations by Mr. F. F. Forbes upon a compound pipe in Brookline, consisting of 9,070 feet of 14-inch pipe and 16,250 feet of 16-inch pipe are plotted. A description of these experiments was read before this Association by Mr. Forbes in 1892. The pipe had been laid 18 years, and the actual friction was 25 per cent. greater than that computed by Smith's coefficients at the lowest velocity and 70 per cent. greater at the highest.

The results of a series of experiments on a 20-inch pipe line used as a pumping main for the city of Hoboken, and described by Mr. Chas. B. Brush in the *Transactions of the American Society of Civil Engineers* in 1888 are also plotted. This was a simple main 75,000 feet long. It had been laid five years. The proportional results in 10,000 feet instead of the total length are plotted, so that the curve would not interfere with those of the other experiments on the sheet. The friction in this case does not exceed the computed friction, except in the highest velocities.

It will be seen that in all of the experiments, with the possible exception of the 30-inch Taunton pipe, the actual friction increases faster with higher velocities than the computed friction, either by the Smith or the Foss formula, which are both practically formulæ of the $\frac{11}{6}$ or 1.83 power. The actual friction curve is nearer in direction if not in amount to the Darcy formula which is one of the second power. The Brookline curve is greater still, or one of the 2.35 power.

It is probable that greater roughness tends to even higher values of the exponent.

I believe this increase in the exponent in the new pipes of Ipswich and Walpole (which while it was evident, was not so marked as in the older lines) was caused by the presence of gates and specials in the line, and that if the velocities had been carried higher the increase would have been still greater.

I wish to acknowledge my obligations to Mr. Geo. F. Chace of Taunton and to Mr. William J. Luther of Attleboro for their courtesy in extending to me the opportunities to experiment on the lines under their care, and also for their kind assistance.

TABLE A.—IPSWICH MAIN.

No. of Test.	9,060 Ft. 12″ Pipe.			1,000 Ft. 12″ Pipe.			1,150 Ft. 14″ Pipe.					
	Gallons per Minute.	Velocity.	Computed Friction.	Gallons per Minute.	Velocity.	Computed Friction.	Gallons per Minute.	Velocity.	Computed Friction.	Total Computed Friction.	Actual Friction.	Per Cent. of Computed to Actual.
1	706	2.00	13.25	353	1.00	.41	664	1.38	.71	14.37	12.85	111
2	860	2.44	19.00	430	1.22	.60	818	1.70	1.05	20.65	19.55	100.5
3	1,020	2.90	26.00	510	1.45	.81	978	2.04	1.45	28.26	27.1	104
4	1,250	3.55	37.40	625	1.77	1.18	1,208	2.52	2.15	40.33	40.3	100

TABLE B.—WALPOLE MAIN.

No. of Test.		6,950 Ft. 12″ Pipe.		8,900 Ft. 10″ Pipe.		Entire Line.		
	Gallons per Minute.	Velocity.	Computed Friction.	Velocity.	Computed Friction.	Total Computed Friction.	Actual Friction.	Per Cent. of Computed to Actual.
1	334	.95	2.61	1.36	8.17	10.78	10.93	99
2	421	1.20	4.10	1.68	12.45	16.55	15.55	106.5
3	585	1.66	7.30	2.40	22.45	29.75	28.80	103.3
4	704	2.00	10.15	2.88	31.35	41.50	40.3	103
5	792	2.25	12.60	3.24	38.90	51.50	51.80	99.5

TABLE C.—ATTLEBORO MAIN.

No. of Test.	6,400 Ft. 16″ Pipe.			10,750 Ft. 14″ Pipe.			375 Ft. 12″ Pipe.					
	Gallons per Minute.	Velocity.	Computed Friction.	Gallons per Minute.	Velocity.	Computed Friction.	Gallons per Minute.	Velocity.	Computed Friction.	Total Computed Friction.	Actual Friction.	Per Cent. of Computed to Actual.
1	402	.64	.85	402	.84	2.80				3.65	3.37	108
2	603	.97	1.76	603	1.25	5.77	203	.57	.06	7.59	8.25	92
3	796	1.27	2.90	796	1.61	9.40	336	1.12	.19	12.49	12.62	99
4	943	1.57	3.96	943	1.96	12.75	543	1.54	.34	17.15	17.25	99.5
5	1,052	1.68	4.80	1,052	2.19	15.40	652	1.85	.47	20.72	21.75	95.5
6	1,083	1.73	5.08	1,083	2.26	16.40	683	1.94	.51	21.99	24.00	91.7
7	1,177	1.88	5.84	1,177	2.45	19.00	777	2.20	.65	25 49	29.00	88
8	1,354	2.17	7.52	1,354	2.82	24.30	945	2.68	.96	32.78	35.50	92.5
9	1,392	2.23	7.85	1,392	2.90	25.50	992	2.84	1.14	34.39	37.00	93

TABLE D.—TAUNTON 30" CONDUIT.

No. of Test.	36,700 Feet 30" Pipe.				
	Gallons per Minute.	Velocity.	Computed Friction.	Actual Friction.	Per Cent. of Computed to Actual.
1	1,033	.47	1.15	1	115
2	1,610	.73	2.55	3	85.2
3	1,960	.892	3.70	4	92.5
4	2,300	1.045	4.80	5	96
5	2,530	1.15	5.90	6	98.5

TABLE E.—TAUNTON 24" MAIN.

No. of Test.	6,000 Feet 24" Pipe.			50 Feet 18" Pipe.					
	Gallons per Minute.	Velocity.	Computed Friction.	Gallons per Minute.	Velocity.	Computed Friction.	Total Computed Friction.	Actual Friction.	Per Cent. of Computed to Actual.
1	4,096	2.91	7	4,096	5.12	.24	7.24	9.87	73.50
2	3,693	2.55	5.80	3,693	4.42	.20	6.00	8.13	73.80
3	3,228	2.29	4.53	3,228	4.04	.15	4.68	6.13	76.50
4	2,785	1.97	3.50	2,785	3.48	.12	3.62	4.75	76.30
5	2,220	1.57	2.30	2,220	2.77	.10	2.40	3.13	77.20

TABLE H.—SOUTH WALPOLE MAIN.

No. of Test.	Gallons per Minute.	8,874' 8" Pipe.		1,735' 10" Pipe.		197' 12" Pipe.				
		Velocity.	Computed Friction.	Velocity.	Computed Friction.	Velocity.	Computed Friction.	Total Computed Friction.	Actual Friction.	Per Cent. of Computed to Actual.
1	660	4.20	80.00	2.70	5.15	1.87	.26	85.41	80.40	1.06
2	591	3.76	65.90	2.42	4.12	1.69	.21	70.23	65.30	1.07
3	533	3.40	54.50	2.18	3.34	1.55	.17	58.01	58.70	.99
4	506	3.24	49.50	2.07	3.04	1.44	.15	52.69	48.00	1.10
5	432	2.76	37.20	1.77	2.23	1.23	.12	39.55	37.00	1.07
6	331	2.12	23.00	1.36	1.57	.94	.07	24.64	22.00	1.12

DISCUSSION.

Mr. Chace stated that during the past season he had seen some things which had suggested ways in which friction might be increased. He had seen places where chunks of lead had been run in as large as a man's arm, and in one case an 8-inch plug was found in a 10-inch pipe, and he thought that cases like this might account for the increased friction in some of Mr. Coffin's observations.

In answer to a question from Mr. Fuller, he stated that the slip of the pumps was estimated in each case according to his best judgment in view of the pumps used. The pumps were duplex pumps except the Taunton pump, where a fly wheel pump was used, and there the slip of the cylinder was practically nothing.

In answer to an inquiry from the President as to the construction of the East Jersey main, Mr. Sheriff stated that he had read a paper before the Association four years ago, giving a full description of it. There is an outer and inner course of plates. In all cases the length of the plates is 7 feet, and the plates lap about 3 inches when they are one-quarter of an inch thick. The nominal diameter was 48 inches and this was the actual diameter of the outer course of plates which were outside of the inner plates at both ends. The diameter of the inner set of plates was 48 inches, less twice the thickness of the plates at that particular point. For the greater part of the way one-quarter inch plates were used. The result of this arrangement is alternate cylinders of pipe 7 feet long and 47½ inches in diameter, and 6½ feet long and 48 inches in diameter.

Four lengths were put together in the shops and painted with asphalt, and after the pipe was placed in position and the joint made, the latter was carefully coated. The hydraulic grade of the line was 10 feet to the mile, but the line did not by any means follow the hydraulic grade. To have followed the river down would have added very much to the length of the pipe, and in cutting across for the first four miles there was difficulty in getting fall enough, and the pipe line was kept pretty nearly up to the hydraulic grade. Beyond that point the descent was more rapid. Air cocks were provided to prevent the capacity of the pipe being cut off by air pockets.

SOME NOTES ON THE FORMATION OF TUBERCLES IN IRON AND STEEL PENSTOCKS.

BY

R. A. HALE, C. E., Lawrence, Mass.

[Read Feb. 12th, 1896.]

The subject of the coating of the interior surfaces of water pipes and the conditions under which the formation of tubercles occur are of great importance to the water works superintendent and engineer, and a few observations on the condition of penstocks used to convey water for power may prove of interest.

The size of the pipes in general for water power is necessarily much larger than for a system of pipes for distribution about a city, and they differ somewhat in construction and material. The pipes which have come under the immediate observation of the writer are, penstocks located at Lawrence and used in conveying water from the canals to the wheels in the mills.

The lengths of the penstocks vary from 50 to 300 feet—depending on the location of the water wheels in the mill. In general they are made of wrought iron, or steel sheets, about $\frac{3}{8}''$ in thickness, riveted together with $\frac{3}{4}''$ rivets, the sheets being joined together either by a lap joint or butt joint.

In the case of lap joints the penstock is built alternately with joints lapping so as to form an inside sheet and then an outside sheet.

In a second method the upper end of each section is slipped into the lower end of the preceding section, similar to a stove pipe joint or a telescopic joint.

The heads of rivets may be countersunk to decrease the roughness. In the butt joints the sheets are butted together and a ring 4″ to 6″ wide riveted about the outside of the sheets, and with the rivet heads countersunk on the inside a perfectly smooth surface can

be obtained, similar to the surface in a cast iron pipe. In connection with measurement of water used by the mills it has been necessary to make inspection of these penstocks and the condition is usually noted.

The coating which is in general applied to the surface is a good quality of asphalt, applied hot with a brush, when the surface of the iron is bright and before rust sets in. Three coats are usually required in specification. A mixture of red lead is sometimes used; and coal tar dissolved and applied hot has been tried.

It is impossible to give a detailed account of the conditions of the various penstocks when first put in with their coatings, but, in general, the condition is known.

The Merrimac river water rapidly oxydizes iron and steel if without any protection, as tools that have been immersed will testify. The mainspring of a watch dropped in one of the flumes while observations were being made was in a deplorable condition before it could be rescued a day or two after.

Without any special divisions as to coatings I will give some results noticed during the past twenty-five years. During the past month an iron penstock 4 feet in diameter has been removed and replaced by one of a larger size. This one removed was of wrought iron, built of inside and outside sheets, and ordinary riveted lap joints. The penstock was put in eighteen years ago and was thoroughly coated with red lead. It was left exposed to the weather for some months before being painted and placed in position, and the probability was that the interior surface might have been somewhat rusty. I was informed that when it was painted that it was brushed thoroughly with old brooms to make it as clean as possible. Tubercles have formed over about two-thirds of the interior surface in a somewhat irregular manner. They vary in size from $\frac{1}{4}''$ to $1\frac{1}{2}''$ in diameter and project about $\frac{3}{8}''$ to $\frac{1}{2}''$ into the pipe. Their distribution on the surface is not uniform with regard to the top and bottom of the pipe, as in some instances they occur on the top and other places on the sides. On portions of the surfaces free from tubercles the red lead forms a good coating, clinging to the iron. On removing one of the tubercles a depression is found pitted in the iron and of the general shape of the tubercle. This depression varies from .002 to .003 feet in depth below the original surface of the iron. It was probable that the surface was not clean when the red lead was

applied and the action of the water started the formation under the red lead coating.

Numerous penstocks coated with red lead are still in use and in fair condition. One set of four penstocks of about 9 feet in diameter, were scraped and afterwards painted with red lead, about eighteen years ago, and have but few indications of tubercles at the present time. At another mill a penstock 3½ feet in diameter put in nine years ago was thoroughly coated with red lead. The velocity of the water is 1.5 feet per second, and the penstock is covered with slime, and the surface is covered for two-thirds of its area with tubercles ½″ in diameter, and projecting ¼″ into the pipe. It was possibly not perfectly clean when first coated with red lead. After a penstock has become dirty and covered with tubercles there is much difficulty in having sufficient time to clean and dry it thoroughly in order to give it another coat. The surface of the iron should be perfectly dry and clean to make the coating adhere properly. Asphalt varnish is the most generally used and easily applied.

Four iron penstocks, about 150 feet in length, were constructed during 1886. They were each 7 feet in diameter, with butt joints and countersunk rivets, and probably given three coats of asphalt. In April, 1888, they were examined and tubercles had begun to form in all of them, but with no degree of regularity. In some instances sheets covered with numerous tubercles were noticed alternating with others almost perfectly clean, with no apparent reason. The tubercles were about the size of a pea, ranging from two to three in a square inch, and projecting from ⅛″ to ¼″ into the pipe. In general there were more on the top and bottom than on the sides. One of the penstocks which is not in constant use and has the head gate closed, has many tubercles formed on the bottom for about a foot in width where the slight leakage has occurred, but the remainder of the pipe is quite clean. In 1889 a growth of sponge was noticed in small patches in the upper half of the section in the first length of about 50 feet. The recent examinations have shown a gradual increase in size and quantity of the tubercles, and new ones appearing on the top and bottom. The velocities of the water have ranged from 1.5 to 2 feet per second. In 1889 a second set of four penstocks, similar to the preceding, were constructed, with diameters of 7 feet and 9 feet and have been in constant use with velocities from 3 to 4 feet per second. In 1894 a few scattering tubercles the

size of a pea were noticed for the first time in three of these penstocks; in the fourth one the sheets were clean for the first 50 feet, but below this point numerous small tubercles had begun to appear. In all of these cases the asphalt showed a clean surface on the iron, with no cracks or lines of separation except where the tubercles were located, when in taking off the tubercles the asphalt was also removed.

The above penstocks were intended to be of the most thorough workmanship, and to have the best protection known at the time they were put in.

A penstock 5 feet in diameter, put in during 1887, or about eight years ago, was supposed to be coated with three coats of good asphalt. The sheet which I have here (Fig. 1) illustrates the condition that existed last year, of the interior surface. This was an impression taken of the side of the pipe, and shows the irregular shape of the tubercles. The tubercles projected from $\frac{1}{4}''$ to $\frac{3}{8}''$ into the pipe, and this sheet shows a fair average of the condition of all parts of the surface. It has been the intention to have this penstock scraped and cleaned, but there has been the difficulty before mentioned of having the water out for a sufficiently long time to permit of thorough drying. In 1887 a penstock 5 feet in diameter was constructed and put in on the South Canal. I was not able to determine the character of the coating at the time, but have understood that it was coal tar, but tubercles formed very quickly, and a growth of sponge had also attached itself. An examination made during 1886 showed the tubercles from $\frac{1}{4}''$ to $\frac{3}{4}''$ in diameter, and projecting $\frac{1}{4}''$ into the penstock. The growth of sponge was very abundant, and in all stages of development.

Patches from 1″ to 6″ diameter adhered to the sides, projecting from $\frac{1}{4}''$ to 1″ into the interior of the penstock. The general character was a compact mass of reticulated appearance, similar to lace work. Another form was obtained with finger-like tentacles from 3″ to 4″ in length, projecting into the penstock, and resembling branch coral. The color was a dirty white, changing during a freshet to a brownish color from the sediment in the water. When exposed to the air it decomposed rapidly with a very disagreeable odor. The sponge was most abundant in penstocks at the lower end of the South Canal where the water was quiet and the velocities through the penstock did not exceed 1.5 feet per second. On the

Fig. 1.

North Canal much smaller quantities have been found. In wooden penstocks much less growth has been found, although it may be probably due to location and higher velocities than the character of the surface. In 1893–4 very small quantities were observed, and last year only slight traces of it were found. It apparently grew equally thrifty whether attached to the tubercles or smooth coating of an iron penstock.

One other penstock to which I wish to call attention is located on the South Canal. It is made of wrought iron with inside and outside laps, about 6½ feet in diameter. It is about 250 feet in length and was put in during 1881. I was fortunate to find the party who coated the interior of the penstock, and the following facts were ascertained:

The material used was coal tar used in roofing mixed with a composition tar obtained from the gas works; equal portions of each were used. This mixture was heated and applied hot with brushes to the interior of the penstock as it laid on the ground before being put in the trench. The weather was cold at the time, and no facilities were had for heating the pipe, which was therefore quite cold. The condition of the pipe at the last examination, during last year showed a few scattering tubercles on the lower half of penstock about ¼″ diameter and projecting about ⅛″.

The surface in general is very clean and has preserved its coating of coal tar in excellent condition. The growth of tubercles has been remarkably small compared with other penstocks with asphalt and red lead coatings.

The coating of tar can be chipped off by striking with a knife, showing a thickness of about .002 feet. The result of the coating in this penstock is in striking contrast to the preceding one described, which was also coated with coal tar, although nothing definite is known about its composition or application.

The character of the surface when the material is applied is of great importance to the preservation of the material, whatever coating is applied, and the varied experience shows that great care must be used in its application. In regard to other coatings, a steel penstock 8 feet in diameter and 200 feet in length has just been completed during the last month, and was coated with three coats of asphalt varnish, made by Webb & Co., which is claimed to be superior to the asphalt as usually applied. It will be of interest to notice

if the tubercles will form as rapidly as on the penstocks with other coatings.

A valuable paper has just been presented by President Fitzgerald before the American Society of Civil Engineers on the flow of water in pipes in which the condition of the interior of the cast iron pipe is referred to, and that the tubercles had a small central point of attachment and spread out over the coating, which was not disturbed. As far as noticed in the Lawrence penstocks in removing the tubercles the coating is also removed or destroyed of the same area as the size of the tubercle.

Many of the members will recall the interesting trip to Kendall & Sons, in Cambridge, to see the Sabin Process of coating the 36-inch pipe that is used by Cambridge in its new supply. It will be of great interest to hear from Mr. Hastings in regard to the character and life of the coating from which so much is expected.

In closing, the only conclusion that can be drawn is that great care must be used in the application of the material used, and that the surface of the iron or steel must be bright and clean and free from any rust. The coal tar has shown excellent results in one instance and very poor in another, and in such cases there may have been a difference in the surfaces to which they were applied. The cost of red lead is probably double that of asphalt or coal tar, and the results do not always warrant the increased cost. The experience of an old boiler maker for the past 25 years will be of interest. He says that the very best paint for penstocks to stand wear is coal tar put on hot; the next best paint is red lead and oil mixed as thick as it will run. Two coats of either, well put on, will give the best satisfaction.

To those who wish to pursue the subject farther, I would refer them to papers of M. P. Wood, Esq., of the American Society of Mechanical Engineers, and read at the meetings of June, 1894, December, 1894, and June, 1895, on the subject of Rustless Coatings for Iron.

DISCUSSION.

In reply to questions from Mr. Winslow, Mr. Hale stated that as the water passing through the penstocks of the Essex Company was used only for manufacturing and not for drinking purposes, no observations had been made as to whether or not it was affected by the red lead coating on the iron.

Mr. Brackett thought that the reason why coal tar acts as a preventive against the growth of tubercles in some cases but does not do so in others is because there are so many kinds of coal tar. Anything that is black goes by the name coal tar. He was also of the opinion that sufficient attention has not been given to the coating of pipes, which is a subject worthy of careful study. The results of Mr. Fitzgerald's recent experiments show, that the capacity of pipes may be decreased 25 per cent. in 15 or 16 years, and mean a most serious loss, and if a coating which will prevent this can be found, it is worth a great deal to any place or to any man who can discover it. He stated that he was making some investigations as to the coating of pipes for the Metropolitan Water Board.

Mr. Hammatt asked for the experience of members as to the use of paraffine for the coating of pipes. No response was obtained.

At the request of Mr. Walker a gentleman from Winchendon told of a pipe which had been down over 30 years and which had maintained its full capacity. It was an inch gas pipe originally unlined, and in three years it had become quite filled with rust. He took the pipe up and heated it and shook the rust out, and afterwards dipped it in some tar with which he was covering a roof, and put it down again, and the pipe is still in good condition. The case was particularly interesting, as the pipe had rusted badly before the tar had been applied to it.

In reply to a question from Mr. Fuller, Mr. Hale stated that he had not observed any special difference in the protection, whether the coating had been applied to the metal before it had ever rusted, or whether it had first rusted slightly and afterwards been coated. In general it was intended to have the iron in a first-class condition and with a clean surface free from rust when the coating was applied.

THE APPEARANCE OF CHARA FRAGILIS IN THE RESERVOIR OF A PUBLIC WATER SUPPLY.

BY

F. F. FORBES, Superintendent Brookline, Mass., Water Works.

[Read Feb. 12, 1896.]

As far as I am able to learn, no trouble in water supplies in this country has been traced to the aquatic plant, Chara Fragilis, until the past season, when a case of this kind was brought to the attention of the writer. One reason for this lack of knowledge may be that Chara Fragilis differs from most of the other organisms which cause unpleasant tastes and odors in water supplies in this particular, that it is not free swimming, but attaches itself by small rootlets to the bottom or sides of a reservoir or pond, and usually remains in one position during its life. Its comparative slow growth, coupled with the probability that during its earlier stages it is a harmless water plant, may further explain the dearth of information on the subject.

In the manner of its development it usually forms paleish green patches on the bottom of the bodies of water in which it lives, four or more feet in diameter and two or three feet high. These patches are made up of numerous long, thin stems, perhaps a sixty-fourth of an inch in diameter, bearing whorles about two inches apart of six to twelve needle-like leaves. The stems and leaves are usually covered with a calcareous incrustation.

It has been stated that the plant holds itself in place by small rootlets; these are not true roots, however, but simply a means of holding on, and this plant in common with the Algæ, receives its food directly into the plant body from the water in which it grows.

Chara Fragilis, however, requires a certain amount of lime in solution, and without this mineral solution it will not thrive; we should not therefore expect to find it in waters like that supplied to

the City of Boston for instance, or in fact in many other waters of New England, but may expect it in limestone countries.

The odor it imparts to water is an exceedingly disagreeable one, and one not easily forgotten.

There are many other species of the genus Chara, but most of them are perfectly harmless, or at least no more objectionable than lily pads and similar water plants. The genus Chara is a very old one; some species occur in a fossil state in the Secondary (Jurassic) strata, and in the Tertiary of Europe they are very abundant.

The following description is copied in part from a standard Botany of Thallophytes: "The Characeæ consist of only a comparatively small number of species. The presence of certain species may be detected by the foetid odors of sulphretted hydrogen given off when decaying. Some authorities attribute the odor to the presence of a special substance called characin. The typical genus Chara is distinguished by its power of extracting calcium carbonate from the water in which it grows, the whole plant becoming thus covered with a calcareous incrustation."

A brief description of the case which forms the subject matter for this paper is as follows: The water supply of a city in a neighboring State became very unpleasant to drink last August. The cause of the trouble was not apparent to those in charge and the writer was asked to make a personal examination of the different reservoirs, and if possible locate the trouble. The water in all the reservoirs except one was found to be good, and this one had considerable shallow flowage. The bottom of the shallow parts were nearly covered with a growth of Chara Fragilis. It became evident to the writer that the whole mischief was caused by this plant, and later information has fully corroborated the conclusion reached at that time. The reservoir in question was at once drawn off and the plants removed, since which time the water has been uniformly good.

DISCUSSION.

In answer to an inquiry from the President, Mr. Whipple stated that he had never met the organism mentioned by Mr. Forbes. Mr. Forbes stated that the reservoir mentioned was in Central New York and that the water was quite hard. He further stated that in parts of Europe much trouble is experienced from this plant, but that this was the first case that had come to his attention in the United

States. He was quite sure that the trouble was due to this organism and not to any other matter which might have been stirred up in cleaning the reservoir. The bottom of the reservoir was irregular, and it was only found in the places that were comparatively shallow and it apparently depends for its growth upon the light that gets through the water. The bottom of the reservoir was of clay and had not been cleaned for a long time; there was but little mud upon it. The stems grow several feet long and the bottoms of the plants may be decaying while the upper portions are still growing. There is but little odor while the growth is still active, but in this case the odor from the whole mass was very unpleasant.

RECORDING PRESSURE GAUGES—THEIR USE AND ADVANTAGES.

BY

FRED. G. PERRY, Pawtucket, R. I.

The subject of recording pressure gauges is perhaps old and now little discussed, but to me, to whom the matter is comparatively new, the study of the gauges and their records is exceedingly interesting.

On the system of the Pawtucket Water Works we have seven Edson recording gauges in constant use; five are for recording water pressures and two for recording steam pressures on boilers. An eighth gauge we use as a spare one to replace any of the set gauges that may be removed for any cause, as for adjustment or cleaning. Gauges are located at each of the pumping stations, at the main office of the Department, which is in the center of the city, at the construction shop, which is near the river, and at the office of the Pawtucket Manufacturing Company, which is west of the center of the city.

The gauges and charts are set in places convenient to the sight of interested parties during the entire day, and we are made aware of unusual draughts, leaks, etc., ofttimes very promptly. We are sometimes warned of the existence of a leak half an hour before the location is reported to us. In the meantime we have prepared ourselves and are ready to respond quickly. To the engineer in charge of the pumping stations the gauges have become invaluable. By means of them he has a constant and permanent record of the pressures maintained at each point, and any unusual fluctuation is noted and inquiry immediately instituted to find the cause.

In very dry times some of our large factories, especially those which have departments for dying and bleaching, call for large quantities of water on short notice, or rather without any notice, and in such cases the gauge performs a valuable service. For

instance, a sudden drop of 10 pounds in the normal pressure of 120 pounds is noted at the pumping station. The engineer at once telephones to the office and reports the same, with an inquiry to know if we have noted the drop on our gauge, and if we know of any leak or heavy draught. Sometimes we are aware of the cause and state the same to him, and he governs himself accordingly. If we are not aware of the cause we at once take steps to inform ourselves, and generally we succeed in finding it. We at once communicate with the parties where gauges are located to inquire if any drop in pressure has been noted by them, for by this means we are sometimes enabled to get a correct idea of the locality of the draught more quickly; we then set out to find the exact locality and the reason for the unusual flow.

Complaints of a lower pressure than usual from firms using the city water for boiler feed, and who feed direct without the aid of pump or injector, are always investigated by means of recording gauges placed on the line from which the supply is taken.

We have had a special gauge constructed by the Bristol Manufacturing Co., of Waterbury, Conn., as we were unable to find in the market a gauge that met our views. The difficulty with the ordinary gauge is that the space between the pressure lines is not great enough to show clearly the pressure in pounds, and also the time scale is too small to show accurately the length of short, heavy drafts. This gauge is portable, and is inclosed in a suitable box or case, and can be attached to a hydrant or faucet or corporation tap by means of a hose, pipe or other convenient means. This is a very useful apparatus, and we should not like to be without it.

In case there is reason to suppose that a party is using water surreptitiously, the gauge is quietly attached at a proper point, the chart is set and the door locked, and another visit is made within twelve hours, and if it is wished to continue the observation, another chart is placed on the cylinder.

If your suspicions are well founded the pressure line recorded on the chart will show to you when the flow occurred, how long it lasted, and by observing the number of pounds drop you can tell very nearly the size of the opening used. You then have in your possession a silent but indisputable witness, and in our experience, when shown to the interested parties, the chart generally settles the argument.

The recording gauge served this department well at the time of the famous trial of fire hydrants on September 19th, 1889, when seventy fire streams were played at once, when, to quote from the 10th annual report of our former Superintendent, Mr. Edwin Darling, to whose untiring energy and zeal the City of Pawtucket is largely indebted for a water works system second to none, "the Chief Engineer of the Fire Department was invited to play seventy fire streams at once, which was successfully accomplished, holding eighty pounds pressure during the time the test was made. The test was made on the twenty-inch force main, three and one-half miles long, leading from the pumps through the center of the city to the storage reservoir on the heights at an elevation of 301 feet above tide water. Four thousand and forty feet of this main were used, and the streams were taken from nine six-wayed and eight two-wayed hydrants. Six Edson recording gauges were placed on the line, located so as to give the best results of the loss of pressure. By the use of these gauges we are enabled to state facts which we should have been unable to do without them. We challenge any water works in the United States to play seventy *one inch* fire streams through fifty feet of hose and maintain eighty pounds of pressure during the trial, the pressure to be verified by recording gauges placed in suitable position on the line of the pipe."

The recording gauge played a highly important part in this test, as it placed on record and beyond dispute in the future the exact pressure maintained.

In closing I cannot do better than to again quote from the same authority, with our hearty endorsement, where he says: "No well conducted water works can afford to be without recording gauges; they not only verify the pressure on the mains, but detect leaks and the opening of hydrants or any heavy draughts of water for legitimate or illegitimate purposes, and, when properly located, they will in my opinion pay for themselves within one year."

DISCUSSION.

MR. WHITNEY. I should like to ask Mr. Perry as to whether or not it has been possible to obtain results showing the force and amount of water-hammer, and if so for how long a time would they register. I believe that Mr. Darling had that in mind, and there has never been any special report from him in regard to them.

MR. PERRY. The registration of the gauges is limited solely by the length of the roll of paper put on them. I think they last for about a month as a rule. The gauges I had reference to, which were made for us by the Bristol Manufacturing Company, were ruled for only 12 hours so as to give a greater space between the hour lines and give more accurate records for such short periods as five minutes. With the regulation Edson gauge, which is ruled, I think, for about a month on the chart, the hour spaces are only about ¾ of an inch, and a 5-minute flow on that would show a mark on the gauge very similar to that from a water-hammer, which would be all in one continuous line. If the gauge is speeded up enough you get the duration of the flow. You can decide then definitely whether it is due to water-hammer or some one drawing from a 6-inch butt, and in five minutes there is quite a little water drawn if it is under such a pressure as we have. You can decide then whether it is a draft or water-hammer, and that was our reason for having the dial made on a 12-hour scale. A 24-hour scale would be one-half as large. On the gauges Mr. Darling referred to, the hour marks were about ¾ of an inch, and if my recollection serves me—I was not connected with the water works at that time, but was with another city department and recollect the test very well—they maintained the flow of water for about eight minutes, and that was as long as the streets would hold it. They could have maintained it till the pressure in the reservoir dropped. I think it was figured at that time that they could maintain that pressure for somewhere between two and three days.

MR. HASKELL. We have a good many bursts in our water pipes, mostly occurring in the night, and they are liable to do a great deal of damage. We keep a couple of men in the stable in readiness to attend to them and to shut off the flow of water as quickly as it can be done. Now, you cannot always depend upon the men to stop these bursts at once, and they may tell you any sort of a story they are a mind to in the morning, and while the bursts may have run a couple of hours it may be reported that they have been shut off in ten or fifteen or twenty minutes. It makes a great deal of difference when a stream of water is running into a house whether it runs 30 minutes or 5, and I think it makes the men a little bit livelier if they know that, whatever their report is, and they always are supposed to report when the leak is discovered and

when it is shut off, all I have got to do is to look on the pressure gauge to see what they have been doing. Perhaps it hurries them up a little bit and makes them do their work more promptly.

Mr. FULLER. I would like to ask Mr. Haskell whether he has any relief valves at Lynn, and if he has, whether they do not prevent breaks?

Mr. HASKELL. Wherever there is an elevator or anything of that sort which requires the opening and closing of gates, we put in a relief valve, but not in the streets.

Mr. FULLER. Wouldn't that be a help to you in saving some of your breaks?

Mr. HASKELL. I don't think it would at all. Our leaks are not occasioned by the water-hammer. It is a little peculiar condition of water pipes when an additional pressure of one pound is going to cause a pipe to burst, and I almost hesitate to tell you, but I will tell you what we have found. Our pressure at night in City Hall at our gauge runs up to 60 pounds. There is a portion of the time in the night when there is very little use of water, and we hold back the water from the reservoir in part, holding the rest in reserve until there may be a conflagration which needs it. We do not allow our pressure to go below 40 pounds at City Hall in the day time, and it never goes above 60 at night. We put in a large main for fire supply some years ago, and the Water Board were very anxious after this was put in to have the water turned on to see what it would do. I cautioned them against anything of that sort, for I thought in all probability it might occasion trouble. Well, one evening when the Water Board was in session they got anxious and they said they must have it turned on so they could see what it would do. The gate was opened and the pressure seemingly hadn't begun, you couldn't see that it was the second pound above, when we got the report of a break and we had to shut down. Well, there were six breaks before we got through with it, and it cost over $200 to repair the damage caused by that little additional pressure.

MR. RICHARDS. If I understand Mr. Haskell correctly, he has a difference in pressure of about 20 pounds between day and night. If there is such a difference that might readily account for the great number of leaks reported.

MR. HASKELL. We don't intend to let the pressure go below 40 pounds at any time, and the 20 pounds represent the extreme variation.

Mr. PERRY. As a recent instance, I will mention the case of a corporation in town that wanted to use a good-sized stream to bore out a culvert cheaply, and we granted them permission to make a temporary 6-inch connection providing they would report to us the length of time which they used it. They reported that the gate was open about twenty minutes, while the nearest pressure gauge showed a drop of some 10 or 12 pounds in the pressure at the time I knew they opened the gate, and that instead of some 20 minutes they had had it open about 40 minutes. There was a 6-inch stream of water going out at a pressure of 120 pounds for 20 minutes longer than they said, and that is considerable water for a man to borrow.

Another instrument which we have recently installed with great success is a recording gauge for showing the height of water in our Stump Hill Reservoir, which is our pressure reservoir, having a capacity of about 20,000,000 gallons.

Mr. HOLDEN. What kind of a gauge is this you have at the the reservoir?

Mr. PERRY. It was made by Mr. George E. Winslow. We had this gauge in operation in the tank in the shop about a month before we put it into the line and it worked to absolute perfection.

Mr. COGGESHALL. I think I should like to ask Mr. Perry with reference to leaving his recording gauge near a hydrant. Do I understand he puts it in the box and leaves it connected with a hydrant in the public street?

Mr. PERRY. The Bristol gauge, with which I presume many of the members are familiar, is a flat gauge and can be put in a box which slides under a buggy seat. The other gauge required a square box, and it was bulky. We enclose it in the box so we can lock it up, and, if necessary, we leave it on the street, but when this is done we leave a man with it. It is in a good, substantial box, in the form and nearly the size of a dress suit case, and is much more convenient than the other form.

Mr. CHASE. One allusion of Mr. Perry's touches a familiar subject in my own experience, and I presume in that of others. I refer to the apparent baneful effect the use of water has upon veracity. No matter how irreproachable a man's morals may be, as soon as he becomes a consumer of water than he loses all desire for truthfulness, and will often go beyond that and help himself to his neighbor's property without let or hindrance. There seems to

be a field open for this Association when it shall have done all it can to aid in the furnishing of irreproachable water, and that is in the inculcation of irreproachable morals on the part of consumers, so far as the taking of water which does not belong to them is concerned.

MR. PERRY. If you will indulge me once more, Mr. President, we recently had reason to think we were not getting paid for all the water a certain consumer was using. We talked with him in a friendly and confidential way, and he was very sure that no water was used on his premises but what came through the meter. He took his supply through a meter, but there was also a fire supply through the corporation premises. We investigated, and found that at times they had from one to three lines of 2½-inch hose attached to the fire hydrants and played them directly into the vats of the concern. He was very loathe to believe it, in fact he would not believe it. He said his men told him that they did not use those hydrants, and Mr. so-and-so had been with him for 20 years, and he would believe what he said. Well, we followed it up by attaching the pressure gauge and we got the positive record on the chart, and when we got it where we wanted it we called him to the office. The result was he found out that his employes had used the hydrants without his knowledge or consent, and he very promptly settled for it and saw that the use was discontinued.

MR. FULLER. I would like to inquire how near the recording gauge was located to the premises in this particular case?

MR. PERRY. Within about 500 feet.

WATER FILTER AT THE MILFORD WATER WORKS.

BY

FRANK L. NORTHROP, Superintendent.

[Read March 11, 1896.]

The water supply for Milford is from wells, of which there are three about 25 feet in diameter, also a basin on the Charles river from which the water for fire purposes has been drawn. Since the construction of this filter, however, there has been water enough from the wells and filter for all uses.

For some years past the supply from the wells has been low during the summer season for about five months, the balance of the year they have supplied a quantity sufficient for domestic and manufacturing purposes.

When low we were obliged to draw from 300,000 to 400,000 gallons of unfiltered water from the river basin in which was considerable sediment and color. In the spring of 1895 we concluded to put in a sand filter which was constructed as shown by the blue prints present.

The construction was begun by excavating a hole in the ground about 225 feet long, 9 feet deep, and from 20 feet to 50 feet wide. The bottom was graded toward the middle and from each end toward the center, and from the center toward the well, so the water would run by gravity into this well. Having completed the grading we laid the tile pipe of various sizes with open joints—the pipe entering the joint about $\frac{1}{8}$ inch. Small cobble stones about 2 inches in diameter were then carefully placed by hand over all the pipe and bottom, as shown on section drawing.

From this the size was graduated to $\frac{1}{16}$ inch, which we got by screening. Sand was then filled in to a depth of about 5 feet, and graded from each side up to about 8 inches higher in the center.

A brick gutter was laid around the edge from the settling basin to prevent washing the sand when the water enters from said basin.

This settling basin is supplied thus, a pipe from a gallery in the Charles river basin, built to prevent the mud from washing in—a serious drawback which we have to overcome.

We use the middle of the three wells for a gallery. This gallery is connected by a brick conduit with the well nearest the pumping station, from which the water is pumped. The supply pipe from the filter runs into the well about 15 feet from the bottom. The quantity of water supplied by the filter is regulated by a 15-inch gate, as shown on the blue print.

We found by filtering the water through 5 feet of sand that practically all the color and river silt were removed, making it nearly as clear as well water, which is considered very good. We are also enabled to keep our wells up from 6 feet to 12 feet all the time, thereby saving much of the lift we have always been obliged to encounter. The wear and tear on the pumps is much less, which is a saving and a great benefit to pipes and machinery generally. Our lift previous to building this filter was from 26 feet to 28 feet. By experimenting with this filter we find there is no trouble with air although but one grade of sand was used. We account for this by proper handling. By letting the water down a while at night and allowing it to filter through the lowest part, leaving about one-third of the highest part uncovered, and then letting water on very slowly, the filter working at the same time so as to drive the air up through the center, that air is expelled and the filter will run longer without cleaning.

The cost was about $800, but would have been much more had we not had the sand and stone on hand.

DISCUSSION.

MR. HASKELL. I would like to ask if there was any analysis made of the water at any time before it entered the filter and after it came through, to see how the filter operates.

MR. NORTHROP. As the water in the river analyzes very good I haven't gone into it particularly. The dirt was what we were trying to get out, and as we could see the filter did that we haven't had the water analyzed at all. It certainly took most of the color out; there was some little color left, but mixing the water with the well water "half-and-half," made it look nearly as clear as the well water itself, which is very clear.

MR. THOMAS. I would like to inquire of Mr. Northrop if he has any trouble with the filter freezing, or how he prevents it from freezing?

MR. NORTHROP. When we put this in we didn't put it in for winter use, as we have water enough in the winter time, but as our engineer and firemen don't like to work any more than anybody else, they have run it all winter with ice on top of it. As the people in the town haven't found any fault we have in that way saved coal and labor.

MR. FULLER. I would like to ask Mr. Northrop how often he has to clean this filter?

MR. NORTHROP. Last summer, when we were running on an average of about 400,000 gallons, and by the way, this filter is only about a quarter of an acre in extent, we cleaned it out about once in six weeks. It took four men about a day to clean it. Since last fall we haven't cleaned it at all, and I should say it is now getting clogged up some, but of course there isn't as much sediment in the winter as in the summer, and I think there are now about 100,000 gallons a day going through it. Last December was the last time we cleaned it.

MR. THOMAS. I supposed it would be impracticable to clean it in the winter without taking the ice off, and my object in inquiring was to find out if he had any means of taking off the ice.

MR. NORTHROP. I don't see how it could be cleaned without taking the ice off, and we haven't cleaned it, as I say, because we have water enough without it in the winter.

MR. CHACE. I would like to ask Mr. Northrop a question which hasn't anything to do with the filter, but as he has a direct pumping system, I would like to inquire how many fires he has had that he could not take care of without fire engines.

MR. NORTHROP. I couldn't answer that question exactly, because we have always used fire engines; that is, we have two engines in town and one is always run out in case of fire. But a great many times I have wished it had been left in the house, because it is attached to one side of a hydrant and then they complain because they don't get a good stream from the other nozzle. I do not think there has been a fire in town in the six years of my administration that we could not have handled, and there isn't a building there we couldn't throw over. We have 150 pounds pressure at the lowest point, and that is all the firemen want.

ANCHOR ICE.

BY

R. C. P. COGGESHALL, Superintendent, New Bedford, Mass.

[Read March 11, 1896.]

The Mt. Pleasant distributing reservoir of the New Bedford water works system has been used since water was first introduced into that city in 1869. Its inside dimensions at the flowage line are about 425 by 335 feet, and when full it contains 15,000,000 gallons, and the water is 18 feet deep.

In connection with this reservoir there is a gate-house, which is located at the foot of the inside slope wall, and about midway along the easterly side. It contains two chambers. The northerly one is kept dry, and through it passes the original 16-inch force main which formerly discharged very near the opposite side of the reservoir. The southerly chamber contains the screens through which water passes to the distributing mains.

Eleven years ago a second force main, diameter 30 inches, was placed from the pumping station to this reservoir. It passes over the easterly embankment and discharges over a weir located in the slope wall, at the space between the gatehouse and the top of the slope. After this second force main was laid, the original 16-inch force main was so connected, and gated, that it may be used at discretion, either as a force or distributing main. When there is reason to do so the pumping may be direct into the distributing system, and the surplus water in this case, passes through the screen chamber into the distributing reservoir. That it is occasionally necessary to adopt this method of pumping, will appear later.

With this brief description of the conditions which exist, I now come to the experience which is the title of this paper.

Occasionally during the cold weather of past years, under conditions which are well understood, the supply of water from this reservoir has been suddenly cut off, by reason of "anchor ice" forming a complete barrier in and around the screen chamber.

When the conditions are ripe, it quickly solidifies against the screens suddenly forming an ice dam, and preventing all passage of water. That remaining in the lower side is quickly drawn away by the consumption of the city. Thus, a pressure is almost immediately established against the screens, under which they invariably yield and become badly wrecked. The ice then rushes into the open ends of the distributing mains, choking them, and completely cutting off all connection from the distributing reservoir.

Several years ago, when the works were in their infancy, this trouble was a much more serious matter than now. It always occurred well into an extremely cold and blustering night, when the waste of water to prevent freezing, added to the regular legitimate consumption, caused a considerable portion of the distributing system to be completely emptied before the trouble was discovered. This was some years before telephones were in use, and consequently a long time would ensue after the first discovery, by some consumer, that he was deprived of his supply, until the superintendent was called from his bed, and he in turn had collected his men at the scene of action. In those days there was not so much known concerning the mysterious movements of this troublesome visitor, in connection with reservoir supplies as now, and when the superintendent was notified of the failure of the supply, I imagine that he was puzzled to account for the cause, and probably considerable time may have been lost on account of this uncertainty. I remember one occasion, about 1873 or 1874, when the water had been cut off during the night, that at 10 o'clock in the morning no water could be drawn at the city hall, and it was some time later before the pressure gauge began to indicate that the supply was returning. In those days the average daily consumption was light, and a few hours each day sufficed to do all the needed pumping, consequently no employe was retained at the pumping station over night.

A few experiences like that just related convinced the Water Board that a watchman at the gatehouse of this reservoir through the coldest nights was a necessity. It was thought that he might prevent the formation of the solid mass of ice against the screen by breaking it up and stirring it with long poles and rakes. His efforts in this direction proved entirely futile, and the only good which he rendered was to call for help, when the trouble occurred, with as little loss of time as possible. It was now noted that this trouble

would not occur when the surface of the reservoir was covered with ice.

Then came the early days of the telephone, and increase of work at the pumping station soon led to a night watchman being retained there. A pressure gauge was fitted with an electric alarm which rang with a few pounds reduction of pressure. This warning bell has since proved useful on several occasions. As the unwelcome visit has always occurred during the night, it would be at a time, during the earlier years of the works, when the pumping machinery was not working.

It was found, however, that a supply could always be obtained through the 16-inch force main which had its opening, as previously stated, on the opposite side of the reservoir from the gatehouse, or on the windward side during this trouble. This seemed to indicate that while the ice crystals were forming upon the water surface at all parts of the reservoir, to a greater or less extent, this action was intensified at the extreme lee side, where the agitation of the water by action of the wind, was of course much more vigorous. Here all the rapidly forming crystals seemed to be driven by the wind and huge masses would soon collect.

During the past ten years this trouble has been cared for wholly by the pumps, which are then changed to operate directly into the distributing system, and if possible, to create enough pressure to drive the ice back from the screen chamber. The screens are, however, apt to be more or less damaged whenever this phenomenon occurs. The fierce wind and strong lower currents carry the crystals to the bottom portion of the screens and gate chamber, where they quickly adhere, before their presence would be apprehended by surface appearances. At such times an attempt to remove the screens is often met with failure, by reason of their being held firmly in place by the ground ice formation. In such cases the ice quickly collects and the barrier is soon completed and the destruction of the screens assured.

When this does occur then the connection with the reservoir is made by means of the old 16-inch force main as heretofore described. If, however, the screens can be removed, then the warmer water from the pumps through the distributing system soon forces a passage, making a tunnel, as it were, through the barrier of ice completely filling the gate chamber. Thus the ice may remain attached

to different portions of the gate chambers for two or three days, but there seems to be no trouble in keeping this tunnel open through into the reservoir, as long as the pumps are kept in motion, and pumping a little more than is being consumed.

The consumer is, however, no longer aware of any difficulty as the pressure upon the mains is not allowed to drop many pounds before it is again regained by the pumps. During the past ten years we have had seven visits, and the ice within the gate chamber after it has formed, has remained from one to three days.

The following statement regarding anchor ice and its formation is extracted from an article which appeared several years since, in the *Journal of the Franklin Institute*, and is from the pen of that distinguished hydraulic engineer, the late James B. Francis of Lowell:

"Anchor ice is an aggregation of small crystals or needles of ice, forming in the water a spongy mass, easily penetrated with any hard substance. It is frequently found adhering in large quantities to the bottom and sides of the water courses, both open and covered. In clear weather, as the sun approaches the meridian, masses of anchor ice often rise from the bottom of the open channels and float off, sometimes with earth and small stones adhering. It is produced in the greatest abundance in cold, clear, windy nights. It unquestionably originates at the surface of the water, the necessary conditions being that the water should be at the freezing temperature, the air below that point and the surface of the water agitated, either by a current or by the wind. In its first stage the ice is in small detached needles or crystals; if there is little or no current this ice accumulates at the surface and finally consolidates into a sheet; if the current is too strong to permit this, portions of it accumulate in spongy masses, and float along at or below the surface, their specific gravity differing but little from that of the water. In a current of water there is a constant intermixture of the water at different depths, producing a uniform temperature at all depths, and tending to distribute uniformly foreign matters held in suspension. This takes place even in the most uniform and regular channels. Natural water courses are almost always irregular in form; the more irregular the more rapid will be the intermixture.

"The anchor ice being formed in small crystals at the surface, by means of this intermixture, much of that which does not aggregate in masses is carried down from the surface, and is distributed

throughout the whole depth of the stream, much in the same manner as earthy matters are carried along in suspension by currents. These crystals have a strong tendency to adhere to each other or to any other solid bodies they may come in contact with. The adherence can only take place by freezing, that is, by a new formation of ice, and here lies the mystery of anchor ice. How can water become ice without a loss of heat?

"Anchor ice is observed to adhere to surfaces of stone or wood, over which the water is running with considerable velocity, in some cases exceeding 20 feet per second, growing up under this rapid current at the rate of an inch or more per hour. It is clearly not dependent upon radiation in the manner Dr. Wells has shown dew to be formed, for we find the piers of bridges and the interior surfaces of subterranean water courses, where there can be no loss of heat by terrestrial radiation, covered with anchor ice.

* * * * * * *

"Anchor ice commences to form at the surface of water, agitated either by a current or by the wind. The water being at the temperature of 32° Fahr., and the air at a lower temperature, heat passes from the water to the air, equivalent to the formation of a certain amount of ice; the water being agitated and the ice in minute crystals, the latter become mixed with the water before all the ice due to the loss of heat is formed; and, although the crystals are removed from further loss of heat, they will continue to enlarge, until an equilibrium is attained. The amount of ice formed after the crystals leave the surface may be very small, but still be sufficient to cause them to adhere, when, by means of the current, they are brought in contact with each other, or with any other solid at the freezing temperature.

"If this explanation is correct, the freezing process must continne for a considerable interval of time after the crystals leave the surface, as we have found on drawing the water out of a subterranean water course, the whole interior surface of the channel coated with anchor ice, with great uniformity and symmetry, and several inches in thickness. This ice must have formed before it entered the subterranean channel and subsequently adhered."

Our late esteemed member Gilbert Murdoch, Esq., formerly superintendent of the water department of St. John, N. B., had an experience of unusual interest, when, on November 22d, 1880, the works

under his care were rendered useless for 15 hours by reason of the sudden appearance of this ice in the distributing screen chamber.

He made this occurrence the subject of a special report of considerable length to the city government of that municipality. This document is of more than usual interest.

In this case the lake from which the supply is taken was covered with ice, with the exception of a strip of open water about 100 feet in width along the shore in front of the gate house through which the supply to the city passed. This open water was kept from freezing, though its temperature was doubtless below 32°, by the gusty gale which had been blowing for many hours. Here the ice formed and was drawn into the gate house by the inflowing current, gradually collecting and solidifying, until the obstruction to the flow was complete. The supply was restored by removing the screens and cutting an opening through a plank partition which held the frame work of the screens and divided the gate house into two compartments. The aperture thus created allowed the ice mass in the upper gate chamber to pass through to the lower chamber where it found an easy egress through waste gates. As the aperture was enlarged the velocity became sufficiently rapid to destroy and carry out all the ice which had collected in the upper chamber, and ultimately to bring a warmer body of water to the gate house from under the ice covered parts of the reservoir. The danger was now passed, and the waste gates were sufficiently closed to allow the water to rise to its normal height within the gate house, and the refilling of the supply mains begun.

Mr. Murdoch summarizes the conditions under which this ice will form as follows, viz.:

"(1) That ice will and does form in open water under certain meteorological conditions; (2) that at such times it is found floating in fine particles at various depths from the surface; (3) that it adheres readily to all solid bodies with which it comes in contact; (4) that it grows or aggregates rapidly when once it has secured a center of crystalization; (5) that it not infrequently closes submerged culverts and water courses, as well as open canals and aqueducts; (6) that the conditions most favorable to its rapid formation are, open water at or below freezing, a sky clouded by day and clear by night, a high wind, and an air temperature ranging from about 5° to 20° above zero; (7) that it seldom forms in bright sunshine, but

on the contrary is often loosened by this influence and is seen to rise in masses to the surface; (8) that it is less troublesome when the mercury is at or below zero than at higher temperature, and (9) that the trouble ceases as soon as *the surface of the water is firmly frozen over.*"

In the case of New Bedford should be added the condition that the wind must be blowing from the west to north for several hours previous to the formation of the ice. The conditions have never been right for its formation there when the wind has been in any other direction.

After the trouble has commenced the wind may change, carrying the bulk of the ice to the south or even to the southwest corner of the reservoir, but under no condition has ever a trace of ice collection been observed in the northwest corner.

The conditions under which this ice will form have already been fully described, but it may be of interest to have a detailed statement of the meteorological conditions in a single instance as observed at New Bedford placed before you.

1894.	Wind.		Temperature.	
	Direction.	Velocity. Miles per Hour.		
Dec. 27....	NE–SW–NW	from 14 to 29	from 52° to 26°	
" 28 . .	NW	" 10 to 15	" 28° to 9°	
" 29....	NW	" 15 to 18	" 17° to 7°	Ice barrier formed at 10 p. m.
" 30....	W to SW	" 3 to 17	" 9° to 30°	
" 31....	N to NW	" 1 to 6	" 20° to 28°	

The weather during this period was from fair to cloudy.

The barrier formed upon the screens in this case about 10 o'clock of the evening of the 29th, and it was three days before the ice fully disappeared from the gate chamber.

The supplies to the cities of Chicago, Cleveland, Detroit, Montreal and other places have been seriously interrupted in the past by this ally of Jack Frost, and reports which later appeared, descriptive of their experiences during this period which must have "tried the souls" of the officials, are of value.

A very interesting case is related by Mr. James B. Francis in a paper presented to the American Society of Civil Engineers in December, 1886. It relates to a disturbance of the supply to the Carleton district of St. John, N. B.

It occurred in the distributing reservoir of a capacity of about one and three-quarter million gallons, being 18 feet deep when full. This reservoir was receiving its supply, when the trouble came, through a 12-inch pipe at the rate of about 300,000 gallons in 24 hours, with the water drawn down about 10 feet, leaving a depth of water and ice of about 8 feet. The reservoir was entirely frozen over with the exception of an area of two or three hundred square feet directly over the supply pipe. The ice covered parts were about 6 inches thick.

Mr. Francis says: "On the evening of December 8th, 1882, the supply of water to this district suddenly ceased, and so continued for a short time until other connections were opened. On the following morning a hole was cut in the ice, which was about 6 inches thick, immediately over the outlet pipe, where a mass of ice was found, which is described as a kind of slush or minute particles of congealed water; on prying upon it it floated up, and the bottom of it was exactly the shape of the strainer of the outlet pipe, showing that it rested upon it and completely closed up the outlet. The strainer is a copper rose, perforated with holes about one-fourth of an inch in diameter, the marks of which appeared upon the ice. The whole column when taken out, or as much of it as would hold together, was about the size of a barrel, and was composed of minute particles of ice, all standing on end, firmly adhering to each other. On removing this ice the water commenced to flow to town as usual."

Mr. Francis reasons that the discharge of the inlet pipe "must have produced an agitation in the part of the reservoir near the inlet pipe in the form of eddies in various directions, some of them extending to the surface, and the temperature of the entering water being above the freezing point, the result was the open water of two or three hundred square feet over and near the inlet pipe."

He concludes that the "ice which closed the strainer formed on the open water over the inlet pipe, was carried under the ice by eddies and currents, and continued in motion until it reached the strainers."

The conclusions which are drawn from the New Bedford experience may be thus stated:

First—Anchor ice will not form when the surface of the reservoir is covered with ice, therefore if the surface could be permanently covered, shielding the water from the action of high winds, anchor ice would never form.

Second—When it does form, as the winds are always blowing from a northerly or westerly direction, accordingly the troublesome ice masses will always be found on the easterly and southerly sides, while the windward side of the reservoir will be found entirely free of this formation.

If, therefore, the supply for the distributing mains should be taken during these occurrences from the northwest corner, there would seem to be little chance of a stoppage of the supply by reason of anchor ice barriers.

In the design of the new distributing reservoir for the New Bedford Water Works, now under construction at High Hill, in the town of Dartmouth, the engineers, Messrs. Rice and Evans, having this trouble in view, have located the effluent gate-house midway upon the westerly side. This reservoir consists of two basins, each 500 feet square, internal measure. The effluent gate-house will take its supply from the northwesterly corner of the southerly basin, and from the southwesterly corner of the northerly basin. During the anchor ice period it is proposed to draw wholly from the southerly basin.

The question may be asked if the current created by the passage of water to the distributing mains will not tend to draw the anchor ice to the chambers of the effluent gate-house, although located in the northwest corner.

In reply I would say that it is true that in both the Carleton case described by Mr. Francis and the Portland case stated by Mr. Murdoch the supply was taken from the west side of the reservoir. In the Carleton case the trouble occurred under an ice surface six inches thick, and the peculiar conditions attending the formation would have been likely to have allowed the formation of this ice upon the strainer of the outlet pipe whatever part of the reservoir its location might have been. In the Portland case the floating ice crystals found their passage into the gate-house against the prevailing gale. The wind could do no more than carry it to the lee side

of the comparatively narrow strip of open water in front of the gate-house, which was probably not so far away as to prevent the ice collection when it sank beneath the surface from feeling the influence of the current toward the gate-house created by the draft of the distributing main. If the entire lake surface had been open water, possibly the result would have been different, as the gale would have then had an opportunity to have driven the ice formation far away to the lee side of the lake.

Besides there is a vast difference in the winter temperature of New Bedford as compared to St. John. It is seldom that the surface of the New Bedford reservoir is ever frozen. If it does so happen, the ice is very thin and is short lived. So I do not think any current such as might be created by the draft of the distributing main will be sufficient to overcome the action of the strong northwest wind which will then be heavily blowing, while a change of wind to the southeast such as would tend to drive the ice toward the gate chambers is always a warm wind with us and would cause the anchor ice to quickly disappear.

When we have had occasion in the past to draw the supply through the old force main from the westerly section of the reservoir the current did not in the least change the mass of anchor ice from its location upon the easterly side.

Neither does the incoming current from the screen chamber, caused by pumping through the distributing system, drive the anchor ice away in face of a strong westerly wind, and only in a limited way does this current maintain an opening through the ice barrier into that basin as heretofore stated. But the ice stays there as long as the wind remains unchanged.

A change of wind will, however, quickly drive the ice from the gate-house. I have known it to be completely blocked, when a sudden change to an easterly wind would clear it and drive all the ice to the south side of the reservoir. At this time we were deluded with the belief that the trouble had had its run for that time, but the next night a change of wind to its original direction brought back all the ice and packed it into the screen chamber a second time in face of the current flowing into the reservoir from the pumps. From this reasoning we are of the opinion that a supply taken from the northwest corner of the new reservoir basin will never be obstructed by the formation of anchor ice.

We have never had trouble from this annoyance at either the storing or receiving reservoir of our system, and thus our experience is wholly confined to the distributing reservoir, as has been described.

DISCUSSION.

MR. RICHARDS. We have had several appearances of anchor ice at New London and the conditions were about as described by Mr. Coggeshall, with the exception that there was always a sudden fall of temperature, from warm to cold, not necessarily very cold, but, say, to 20 degrees above zero. The particles, as I have observed them, have been about the shape and size of a silver dollar, and the entrance to the gate-house, which was at that time about 10 feet deep and 12 feet wide, was completely blocked with them. It was more like "sposh" than like solid ice; if you ran a pole into it, it would be difficult to draw the pole out. The other phenomena connected with it were very similar to what Mr. Coggeshall has described.

MR. HALE. At Lawrence we have had some very interesting experiences with anchor ice when the river is open. If the river is frozen over we usually have no trouble at all; there seems to be no such formation; but if the river is open we have considerable trouble on cold mornings. At the dam, where there are three feet of flashboards supported by iron pins, the anchor ice accumulates about the pins four or five inches in height; but as soon as the sun appears it melts All along on the dam on a cold morning we notice this phenomenon. The mills are always more or less troubled at the same time with the ice collecting against the iron rakes, and they have men out there with hooks, etc., at work stirring it up so that the water can reach the wheels. I think the ice is very much as Mr. Richards describes it, sort of a "sposh." You can push a pole into it, but it is very sticky and adheres closely

MR. RICHARDS. There is one other circumstance which attracted my attention. I was quite sure that the ice either had formed or had been at the bottom, because it brought up stones and pieces of moss.

MR. COGGESHALL. We have observed the same thing at New Bedford, that the ice has brought up dirt from the bottom of the gatehouse.

MR. SPARKS. My company is, perhaps, a little more unfortunately situated as to anchor ice than the rest of the water companies represented here. We depend upon water principally for power to drive our pumps, and we also have an electric plant. We have 13 water-wheels. I have known within the last five years the anchor ice to accumulate on the gates so that we had to keep men hooking night and day in order to let the water through. We have 48-inch turbine wheels, running under about 11-foot head at about 100 revolutions per minute for our electric plant, and I have known the ice to churn up on those wheels so that it would resemble ice cream more than anything else, and finally stop the wheels entirely. This winter the river has been full of anchor ice for 60 miles. My pump well, that is about 15 feet long, was clogged up for a month before it thawed out. The ice accumulates outside in the river where the water doesn't run very quick, and passes down till it reaches a dam or some place where it commences to clog, and then backs up. We have trouble of this sort every year, and if the river is open we have the anchor ice just the same if the temperature is 10 degrees below zero. It is the worst stuff to contend against I know off. You can't shovel it, or do anything with it. As the gentleman says, you run a pole through it and it is hard to pull the pole out again. A few years ago I laid a water main across the river where the water was some 20 feet deep and it was full of anchor ice. I hadn't had much experience with it at that time and supposed a pipe which would weigh 100 pounds to the foot would go through it, but I found I was mistaken, and the ice had to be stirred up with poles, raised to the surface and taken off with sieve shovels before it would allow the pipe to sink. It is quite strong and will form a dam of itself. This season at our pumping station, after the wheels had been entirely stopped, we dug down close to the racks, and there was a wall of perhaps three feet of anchor ice left between them and the water, and that was absolutely tight, allowing no filtration of water at all. It was of sufficient strength so it wouldn't allow the water to break through it until it was stirred up.

MR. STACY. I don't know that I ever had any trouble with anchor ice in that way, but I would like to know if anybody has had pipes freeze up when the frost is coming out in the spring in a warm day and whether that has anything to do with anchor ice? I had a 6-

inch main freeze up one day when you could walk around the streets with your coat off, and the water was running and the frost coming out. I had another 4-inch main freeze up the same way. I attributed it to the radiation of the heat, a good deal on the principle of an ice cream freezer. I remember another case where they called me about 10 o'clock at night, where a service pipe had frozen in the wall. They had drawn water at 5 o'clock. It was a warm night; raining a little bit. There was a place in the wall around this pipe, where they had dug in for some reason, perhaps to thaw it out at some time. It was one of these cellar walls where the air circulates pretty freely, and the temperature had arisen enough, and there was frost enough behind to make the conditions right, and the pipe had frozen solid for about a foot. I don't suppose that is in the nature of anchor ice, and it works in just the opposite way as far as temperature is concerned.

MR. RICHARDS. I will say that my experience with the freezing of pipes has been exactly similar to Mr. Stacy's. At one time we were a little economical, laying our service pipes too near the surface, and a great many of them froze up, and they always froze when it was thawing above ground.

ELECTROLYSIS.

BY

JOHN C. HASKELL, Superintendent, Lynn, Mass.

[Read March 11th, 1896.

Mr. President and Members of the New England Water Works Association:—

In occupying your time for the brief period of five minutes with an experience paper I will speak upon a subject that has furnished me sufficient material for many experience papers and one which I consider to be the greatest danger that at present menaces our system of water works, namely, the electrolysis of water pipes.

It seems to me to be a danger that is ever present in all portions of our water works where electric roads are in operation, and is more dangerous from the fact that its full extent is not yet known by any one, and in some instances I meet parties that should be better informed actually believing that no danger of this description need be feared in the works under their direction.

My attention was first drawn to this subject during a conversation with the late Hiram Nevons, at that time superintendent of the water works in Cambridge, in which he stated that he had found leaks in service pipes in that city which he believed were occasioned by the action of electricity.

Previous to that time the cause of most of the small leaks in the water pipes in our city were attributed to rust. Upon learning that an hitherto unknown danger menaced our pipe system a careful examination of all supposed rust holes was made to detect the first appearance of the expected trouble. Before any undoubted damage to our pipes from this cause was found, I received additional information about this mysterious agent from a paper read before this Association, in which it was explained that the electric current used in propelling cars possessed peculiar powers, one of which was described practically as follows: That as a drop of water taken by evaporation

from the ocean into the air and driven by the winds into the most remote parts of the earth returns to the ocean, likewise all electricity generated at a power house and used as a motive power to propel cars in various directions and distances would return to the power house in which it was generated.

Always like water following the direction of least resistance or as applied to electricity the lines of greatest conductivity.

After listening to the paper and discussion that followed I began to realize more fully the danger to which we were exposed, as unfortunately the contents and metal of our water pipes furnishes a better course for the passage of the electric current than the earth in which they are situated, and I also recognized that their comparitive safety depended upon a power over which I had no control, namely, an electric railway company.

Upon interviewing the engineers of our electric road as to the probability of any danger resulting to our pipes from this direction, I was assured that no such danger existed, as they could not afford to lose the electric current and that equal facility was given to the return as to the outgoing current. Despite this assurance of safety a leak was soon found in a service pipe, evidently caused by the electric corrosion.

A portion of the pipe was taken out and the ammeter showed a large amount of electricity passing along the pipe. This amount was largely increased during the passage of cars over the spot. There also was sufficient heat in the current between the ends of the pipe to burn the hard wood handle of a screw driver. This trait, however, is more dangerous if it should develop in a building than outside in the earth, and is of more interest to the fire than the water department. The electrician of the railway company, after examining the pipes and seeing the extent of the current, admitted their responsibility in occasioning the leak and promised immediate relief, which was attempted by giving a return wire to the power house and with occasional wires at right angles across the street.

This relief proved to be insufficient, for since our first experience many others of a similar character have occurred, sufficient in number to give us some knowledge of the actual workings of the electric current in our water pipes.

I have here a diagram showing the location of a service pipe which has caused more trouble than any other in the city, having been

renewed four times within three years. The last occasion being on March 9th, 1896, after remaining in the ground thirteen months and ten days. You will observe upon inspection that the damaged portion of the pipe extended but four feet and six inches from the outer rail of the track, the remaining portion beyond the union is still in use although twenty-two years old.

The water main is situated one foot and six inches from the opposite rail and is ten inches in diameter. A service is connected to the engine house two feet from the first mentioned service pipe. This pipe is connected to the main at a point two feet and one-half distant from the outside rail of the road and has been in use twenty years without any serious deterioration. The injured pipes show the danger limit to be situated very close to the outside rail. The pipe was five feet below the surface of the street. The character of the earth is gravel. When excavating to remove the pipe on March 9th, a broken copper wire, intended originally to serve as a return wire to the power station, was found. This wire was situated one foot below the surface of the street, the extreme end being bent downwards and but two feet and seven inches distant from the pipe and without doubt hastened the destruction of the pipe.

I will also present to you a piece of lead pipe that has been in use but six months. The appearances of these pipes furnishes a better object lesson on the effect of electrolysis than any description I could give.

The principal ideas I have gathered from my experience are:

First—That there is at all portions of our city, near the lines of the electric railways, perceptible currents of electricity passing along the water pipes.

Second—That most of the pipes destroyed were within a distance of 2,500 feet from the power house, showing greater danger from the accumulative flow of the current gathered from diverging lines and finally concentrated in the single line to the power house.

Third—That the rapidity of this action is directly due to the amount of the current.

Fourth—That the greatest point of danger to service pipes laid at right angles to the track is under the rails.

Fifth—That the greater depth at which we lay the pipes ensues greater safety.

Sixth—That covering the pipes with several thicknesses of paper

and laying in a bed of cement at those points where trouble is experienced is a protection that we can furnish at small expense compared to the benefit received.

Seventh—That the switches furnish the most dangerous points, plainly allowing a greater escape of electricity than the main tracks.

Eighth—That the electric current may introduce disagreeable or dangerous qualities into the water flowing through the pipes.

We are told by experts who have made a study of the electrolytic subject, that a current passing along a pipe upon meeting a poor joint divides, a part going outside and part inside, and that besides the injury from corrosion great danger exists from salts of iron and salts of lead formed by the electrolytic action, also that the passage of the electric current through the water inside the pipe will destroy all animal and vegetable organisms contained therein, thus furnishing another danger in the nature of impure water, both in taste and odor. Although our first knowledge of this subject seemed enveloped in mystery, enough facts have been discovered to show its dangerous character and the importance of removing it entirely.

Experts agree that a storage battery system would be entirely harmless. This solution, however, cannot be attained until more practical results are shown than can be at the present time.

While there is yet much to be learned in the construction and operation of trolly roads, I have no doubt but that with the joints of the rails well bonded together to prevent the escape of the electric current and a return wire of sufficient capacity to convey the full current back to the power station no serious damage would be caused until the good character of the first construction is impaired.

This latter contingency is ever present and is the most difficult feature to control as the impaired work would, to a large extent, be hidden from inspection under the ground. To ensure comparative safety for our water pipes concerted action should be taken to secure such legislative restrictions as might be deemed the best adapted to prohibit electric roads from permitting the escape of the electric current into our streets.

DISCUSSION.

MR. HODGSON. I would like to inquire whether when the lightning strikes the pipes if the cement doesn't prevent it from passing off into the ground without bursting the pipe?

MR. HASKELL. We have had more experience of that kind than I wish we had. We had a case a few years ago where we supposed there were a couple of bursts. We repaired them and turned the water on and discovered there were others, and the next day we relaid the entire street and found 22 bursts within a distance of 300 feet.

MR. HOLDEN. Have you ever measured the amount of the return current on the pipes with a volt meter?

MR. HASKELL. Yes, sir, I have. I don't know as I care to talk about that, because I am not an electrician, and I have to depend on certain machines with which I am not as conversant as I might be. But on the very first occasion, and I remember that perhaps better than I do the more recent ones, because there have been so many, there were 30 amperes. That was taken by an electrician, not by myself. It was largely increased, almost doubled, on the passage of the cars. There have been even larger amounts than that measured, and while I could get notes that tell the difference in the amounts, I think that is enough, because what we are interested in is the fact that it destroys our pipes, even in small amounts.

MR. HOLDEN. Where do you make your connection to your pipe in measuring the return?

MR. HASKELL. Sometimes when I am doing it for curiosity I go to a hydrant, but when I have a piece of water pipe eaten out there is a section of it cut out that we have to put in again, and I make the connection right between the two ends, right in the place that is gone, and I suppose that gives as good chance to measure it as any, and comes pretty near showing the actual amount of the current, does it not? I ask the question of any electrician who may be here.

MR. HOLDEN. I asked because I have experimented a little on our works, and have made connections between the track and the hydrant, and I have never been able to find any current at all, and it was a question with me whether there wouldn't be some way of finding the current if I were to connect directly with the pipe instead of with the hydrant.

MR. HASKELL. Our works were about the first electric works which were ever put in operation. It was a good while before we really found the bad work in our pipe. As I have said in the paper, if an electric road is properly built, if they have good continuous bonds between the rails, that stops the escape of electricity. As I understand it, the electricity is generated in the power station and

is carried out on the trolley wire. The wheel follows along on that trolley wire and takes up electricity, which is then carried through certain parts of the car until it finally reaches the rheostat. When it arrives at the rheostat it has got to a place that perhaps would be more familiarly known to us as the throttle valve on an engine, and it is ready then to go to work. The electricity goes into the wheels of the car, and it touches the rails, and everything goes smoothly until it comes to a broken connection. When there is any trouble in a joint, or a break, there will be a spark of fire, you can see it go clear across the street. That is an escape of electricity you notice. If it isn't quite as bad it goes into the ground and you don't see it. But all the electricity that escapes is the electricity which gives us trouble. If they have got a good return wire it gets back into that return wire and does not reach our water pipes, but otherwise it is likely to get into them and that is where the trouble is.

MR. COOK. I would like to ask who pays for the renewals, the city or the street railway?

MR. HASKELL. We have paid so far, under certain promises to give us better work. Now, I am not going to find any fault with our railroad people in Lynn, because I recognize the fact that they have done a good deal to try to give us good work, and more than that, we expect to get paid for the expense they have caused. We have had a good many renewals, but have not yet brought it to a head to get the money for it. It is a hard thing to get money out of a railroad company until you have proved that they have got to pay it. It really means a law suit in which you don't exactly know where you are going to come out. And I think action to insure getting the work done in a proper manner in the first place is the vital point in the handling of electricity. The question is not to handle it after it has got into the ground, but to keep it out; that is the important point. I am satisfied now that there isn't a necessity for trouble everywhere, as I thought there was when I first heard this matter discussed. The only point is not to let it get away from the rails at all, but if it does, then we want to catch it just as soon as we can, before it gets to the water pipes, and give it a safe course back.

MR. COFFIN. I would like to ask Mr. Haskell if he has found it to be a fact that the trouble is largely located within a short distance from the power station?

MR. HASKELL. No, sir. As I stated, we find electricity all over the whole line of our water pipes where they are in close vicinity to the electric tracks. Over two miles from our station we had a leak from this cause. In this case the electric road made objections to paying the meter bill. There was a 2-inch supply went into their car-house and it was in low ground where there was a nice opportunity for the water to escape after it passed the meter, and we hadn't discovered that there was a leak beyond the meter before a large amount of water went through. When discovered, we took it out, and that is one of the bills the company did pay, both for putting back the pipe and the extra water which was used. I was a little sorry about that, because I don't like to charge anybody for water from which they don't get any benefit. That was over two miles away from the station. If there is imperfect construction anywhere, I don't care if it is ten miles away, you will have trouble. I don't think distance will save you. For instance, if there is a switch located ten miles away from a power station and there is a break in the joint there, I don't see why they wont lose just as much electricity as they would if the break was near the power station, only you haven't got the accumulated flow of electricity. A small amount, we will say three amperes, might pass through a pipe a long time and not seriously affect it. Comparing the energy to that of water, which we are more familiar with, you see a little bit of water flowing in the gutter up at the top of a steep hill in a hard shower, and it doesn't do any damage there; but as it comes down a little ways it increases in volume and by and by it does do serious damage. Electricity, I take it, is practically similar. When we are way off at the extreme end of the electric line the amount of liberated electricity is very slight; but as we come nearer the station the current from the various lines concentrates until it is sufficient to do serious damage.

MR. COFFIN. My knowledge on electrical matters is somewhat limited; but I have understood from my study of the matter that the danger was confined to within a comparatively short distance from the power station, when the current was run, as they call it, positive to the trolley; and if the current was run negative to the trolley, the dangerous district would be on the outside. That is to say, where the trolley wire is positive the danger district covers an area perhaps of from half to three-quarters of a mile in radius

from the power station, and the danger then is when the current leaves the pipe to go through the ground to the power-house. It is where the current leaves the pipe and goes into the ground, where there is a difference in potential, or, as we would call it in water works language, a difference in pressure, that the danger occurs, and at no other place. Where the current goes from the railroad track, or from the ground into the pipe, there is no danger.

MR. HASKELL. I don't think that can be considered to be the case, because our experience shows there is trouble over two miles away. We did have serious difficulty at one time near the power-house, but that has been entirely remedied and we haven't had the least trouble there for more than a year.

MR. COFFIN. Did you make connections between the return wires and your pipes?

MR. HASKELL. They increased the size of the return wires and they ran more or less lines across the street, as they said, to catch the electricity.

MR. COFFIN. And made connections with your pipe?

MR. HASKELL. No, sir; they didn't connect with the pipes. While some electricians say connections should be made, the electrician of the Lynn company said that wouldn't be the proper thing, and as long as they were doing the work of course I didn't undertake to interfere with them. I think the only truth in the statement that the danger is confined within an area a short distance from the power-house, is that the danger is greater near there than elsewhere; but there is danger at any point on an electric road where the work is imperfect. If there is poor work there will be trouble with the water pipes even ten miles away.

MR. COFFIN. Perhaps I made my statement a little too strong when I said that all the danger was confined to this small district. That is not what the electricians say; but that the greater proportion of the danger is there, and that the danger outside of this district is small.

MR. NELSON. My experience in laying gas pipes in Boston has been something similar to that which Mr. Haskell has had with his water pipes. I put in a pipe in Harrison avenue, something over two years ago, and in less than two years the entire pipe was eaten up. In regard to Mr. Coffin's statement as to the trouble being confined to the vicinity of the power station, I know of a case

in Boston where a 12-inch gas pipe out on Blue Hill avenue, in Dorchester, four miles away from the station, was destroyed. That was a very peculiar case, in that there was a hole eaten in the pipe about as big as a man's fist, and we cut a piece of pipe and put a new piece in and haven't had any trouble since; that was about a year ago. Down on the corner of Dover and Albany street I cut a 12-inch gas main one day to put a T in, and in doing that we didn't shut the gas off but bagged it on each side, and when we were putting in the T, as soon as the two pieces of pipe touched, the sparks came out of the iron and set the whole thing afire, and we had to call out the fire department.

PROCEEDINGS.

ADJOURNED MEETING.

YOUNG'S HOTEL, BOSTON, MASS., Feb. 12th, 1896.

President FitzGerald in the chair; members and guests were present as follows:

ACTIVE.

Abbott, E. L., Boston, Mass.
Bancroft, L. M., Reading, Mass.
Barbour, F. A., Brockton, Mass.
Batchelder, G. E., Worcester, Mass.
Beals, J. E., Middleboro, Mass.
Bigelow, J. F., Marlboro, Mass.
Bowers, Geo., Lowell, Mass.
Brackett, Dexter, Boston, Mass.
Chace, Geo. F., Taunton, Mass.
Chadbourne, E. J., Wakefield, Mass.
Chandler, C. E., Norwich, Conn.
Chase, John C., Wilmington, N. C.
Clark, H. W., Lawrence, Mass.
Coffin, F. C., Boston, Mass.
Coggeshall, R. C. P., New Bedford, Mass.
Conant, H. W., Gardner, Mass.
Cook, Byron I., Woonsocket, R. I.
Cushing, Lucas, Boston, Mass.
Ellis, John W., Woonsocket, R. I.
Evans, Geo. E., Boston, Mass.
Felton, B. R., Boston, Mass.
FitzGerald, Desmond, Brookline, Mass.
Forbes, F. F., Brookline, Mass.
Forbes, Z. R., Brookline, Mass.
Flinn, R. J., Brookline, Mass.
Fuller, Frank L., Boston, Mass.
Gleason, F. B., Marlboro, Mass.
Gould, J. A., Boston, Mass.
Hale, Richard A., Lawrence, Mass.
Hammatt, E. A. W., Boston, Mass.
Harrington, G. W., Wakefield, Mass.
Hartwell, David A., Fitchburg, Mass.
Haskell, John C., Lynn, Mass.
Hastings, V. C., Concord, N. H.
Hawes, Louis, Boston, Mass.
Hazen, Allen, Boston, Mass.
Hodgdon, F. W., Arlington, Mass.
Holden, H. G., Nashua, N. H.
Hyde, H. N., Newton, Mass.
Jackson, D. D., Newtonville, Mass.
Jenkins, G. S., Lawrence, Mass.
Kent, Willard, Narragansett Pier, R. I.
Kieran, Patrick, Fall River, Mass.
Kimball, G. A., Boston, Mass.
Knowles, Morris, Boston, Mass.
Locke, J. W., Brockton, Mass.
McNally, Wm., Marlboro, Mass.
Nash, H. A., Boston, Mass.
Neubling, E. L., Reading, Pa.
Patch, W. W., Fayville, Mass.
Rice, G. S., Boston, Mass.
Richards, W. H., New London, Ct.
Rogers, H. W., Haverhill, Mass.
Russell, Daniel, Everett, Mass.
Salisbury, A. H., Lawrence, Mass.
Shepard, F. J., Derry, N. H.
Shirreffs, Reuben, Richmond, Va.
Stanwood, J. H., Boston, Mass.
Stearns, F. P., Boston, Mass.
Taylor, F. L., Brookline, Mass.
Thomas, R. J., Lowell, Mass.
Thomas, W. M., Hingham, Mass.
Tower, D. N., Cohassett, Mass.
Vaughn, W. H., Wellesley Hills, Mass.
Walker, C. K., Manchester, N. H.
Wallace, E. L., Franklin Falls, N. H.
Welch, J. A., Methuen, Mass.
Whipple, Geo. C., Brighton, Mass.
Whitney, J. C., West Newton, Mass.
Winship, Horace B., Norwich, Conn.
Winslow, Geo. E., Waltham, Mass.
Wiswall, E. T., West Newton, Mass.

ASSOCIATE.

H. R. Worthington, by James M. Betton.
Builders Iron Foundry, by T. C. Clifford.
Chadwick Lead Works, by A. H. Brodrick.
Chapman Valve Co., by E. L. Ross.
Deane Steam Pump Co., by Chas. P. Deane.
Gilchrist & Taylor, by H. N. Libbey.
The Goulds Manufacturing Co., by Mr. Mackie.
Hersey Manufacturing Co., by Samuel Harrison.
The Hydraulic Construction Co., by Wm. D'H. Washington.
Ludlow Manufacturing Co., by Mr. Gould.
National Meter Co., by Mr. Lufkin.
Neptune Meter Co., by W. G. Zick.
Perrin Seamans & Co., by Mr. Bond.
Thomson Meter Co., by E. L. Abbott.
Union Water Meter Co., by J. P. K. Otis.
Walworth Manufacturing Co., by C. H. Polsey.

HONORARY.

The Engineering Record, by C. J. Underwood, Jr.

GUESTS.

Bartlett, R. S.
Crafts, A. N.
Crawford, J. W., Clerk of Water Board, Lowell, Mass.
Crowley, T. M.
Fairbank, John H., Chairman Water Board, Winchendon, Mass.
Felix, Geo. H., President Water Board, Reading, Pa.
Gould, H. F.
Marble, W. F.
Rogers, H. T.
Thomas, H. L.

ELECTION OF MEMBERS.

George S. Jenkins, Mayor and member of the Water Board, Lawrence; Arthur D. Marble, City Engineer, Lawrence; Frank Kimball, Civil Engineer, Boston; Gerald M. Bliss, Civil Engineer, Walpole, Mass., were elected resident members; Emil L. Neubling, Engineer and Superintendent of the Reading, Pennsylvania, Water Works, was elected a non-resident member.

Papers were read by Mr. George Bowers, City Engineer, Lowell, on the "Description of the Second Tube Well Plant at Lowell, Mass.;" George F. Chace, on "Handling Fires While Changing Distributing Mains Upon Important Streets;" Freeman C. Coffin, C. E., of Boston, on "The Friction in a Few Pumping Mains at Various Velocities;" R. A. Hale, C. E., Assistant Engineer of Essex Company,

Lawrence, on "Some Notes of the Formation of Tubercles on the Inner Surface of Penstocks;" and F. F. Forbes, C. E., Superintendent, Brookline, Mass., on "The Appearance of Chara Fragilis in a Reservoir of a Public Water Supply."

Mr. Jackson, at the request of Prof. Sedgwick, showed a photograph, taken by the Roentgen process, of a human hand, showing the skeleton and the exact shape of each bone and the outline of the hand.

QUARTERLY MEETING.

YOUNG'S HOTEL, BOSTON, March 11th, 1896.

The following members and guests were present:

ACTIVE.

Abbott, E. L., Boston, Mass.
Babbidge, P. F., Keene, N. H.
Baldwin, C. H., Boston, Mass.
Bancroft, Lewis M., Reading, Mass.
Batchelder, G. E., Worcester, Mass.
Beals, J. E., Middleboro, Mass.
Bigelow, J. F., Marlboro, Mass.
Bowers, George, Lowell, Mass.
Brown, J. H., Boston, Mass.
Chace, G. F., Taunton, Mass.
Chase, J. C., Wilmington, N. C.
Coffin, F. C., Boston, Mass.
Coggeshall, R. C. P., New Bedford, Mass.
Cook, B. I., Woonsocket, R. I.
Doane, A. O., Newton, Mass.
Ellis, J. W., Woonsocket, R. I.
Forbes, F. F., Brookline, Mass.
Fuller, F. L., Boston, Mass.
Gleason, F. B., Marlboro, Mass.
Glover, A. S., Boston, Mass.
Gould, A. A., Leicester, Mass.
Gould, J. A., Boston, Mass.
Gow, F. W., Medford, Mass.
Gowing, E. H., Boston, Mass.
Hale, R. A., Lawrence, Mass.
Harrington, G. W., Wakefield, Mass.
Haskell, J. C., Lynn, Mass.
Hastings, V. C., Concord, N. H.
Hazard, T. G., Jr., Narragansett Pier, R. I.
Hodgdon, F. W. Arlington, Mass.
Holden, H. G., Nashua, N. H.
Jackson, D. D., Newtonville, Mass.
Johnson, W. S., Brooklyn, N. Y.
Kent, E. W., Woonsocket, R. I.
Kent, W., Narragansett Pier, R. I.
Kieran, Patrick, Fall River, Mass.
Kimball, G. A., Boston, Mass.
Kingman, Horace, Brockton, Mass.
Knowles, Morris, Lawrence, Mass.
Locke, Jas. W., Lawrence, Mass.
Luther, W. J., Attleboro, Mass.
McNally, Wm., Marlboro, Mass.
Northrop, F. L., Milford, Mass.
Noyes, A. F., Boston, Mass.
Perry, F. G., Pawtucket, R. I.
Porter, Dwight, Boston, Mass.
Richards, W. H., New London, Ct.
Shippee, J. D., Holliston, Mass.
Sparks, H. T., Bangor, Me.
Taylor, F. L., Brookline, Mass.
Taylor, L. A., Boston, Mass.
Thomas, R. J., Lowell, Mass.
Thomas, W. H., Hingham, Mass.
Tower, D. N., Cohasset, Mass.
Vaughn, W. H., Wellesley Hills, Mass.
Welch, J. A., Methuen, Mass.
Whitney, J. C., West Newton, Mass.
Winslow, F. I., Boston, Mass.
Winslow, G. E., Waltham, Mass.

ASSOCIATE.

Chapman Valve Manufacturing Co., by E. L. Ross.
Crosby Steam Gage and Valve Co., by Robert Pirie.
Deane Steam Pump Co., by C. H. Hayes.
Hersey Manufacturing Co., by Samuel Harrison.
Gould Manufacturing Co., by Mr. Mackie.
Ludlow Valve Manufacturing Co., by H. B. Winship.
McNeal Pipe and Foundry Co., by Wilmer Reed.
Perrin, Seamans & Co., by L. Bond.
Smith, Anthony P., by W. H. Van Winkle.
Thomson Meter Co., by A. H. Higley.
Walworth Manufacturing Co., by C. H. Polsey.
Wood, Lester E.
Worthington, H. R., by E. H. Foster and J. M. Betton.

GUESTS.

Mayor Beason, Lynn, Mass.
Messrs. Putnam, Jones, Hills, Weaver, and Crawford, Water Commissioners, Lowell, Mass.
J. M. Nelson, Boston, Mass.

Vice President Beals, after lunch had been served, called the meeting to order and said :

I don't know but I ought to apologize for being in the chair to-day, but perhaps necessity needs no apology. The ranking officers are absent, and I will do the best I can in the position in which I now find myself. The secretary has some business to bring before the Association.

The secretary read the names of the following applicants for membership :

ELECTION OF MEMBERS.

Resident Active—Amos Gould, water commissioner, Leicester, Mass.; Andrew Holden, water commissioner, Fall River, Mass.; J. H. Fairbank, water commissioner, Winchendon, Mass.; Arthur N. Cram, water commissioner, Walpole, Mass.

Non-Resident Active—Fred J. Gubelman, assistant engineer, East Jersey Water Co., Jersey City; Louis L. Tribus, hydraulic and sanitary engineer, 80 Warren street, New York.

On motion of Mr. Coggeshall the secretary was directed to cast the vote of the Association for the above named candidates, and having done so they were declared elected.

The secretary read a communication from the associate members announcing that they had selected Mr. Henry F. Jenks, of Paw-

tucket, R. I., to have charge of the exhibits at the next annual convention, to be holden in Lynn, in June.

On motion of Mr. Stacy the president was directed to appoint a committee of five to nominate officers for the ensuing year. It was announced that the committee would be appointed later.

The presiding officer then presented His Honor, Mayor Bessom, of Lynn, who spoke as follows:

Mr. Chairman, when I received an invitation from our superintendent of water works to be with you this afternoon I did not suppose I was to be called upon for a speech. I imagined that my pleasant duty would be to listen, perhaps, to a dissertation in regard to the animalculæ or some of the creatures with unpronounceable names which are in the habit of infesting our waters; and it is a little embarrassing for me to stand here and attempt to talk to gentlemen in regard to a matter with which they are much more familiar than I—not but what I use water upon certain occasions. But in regard to the quality, and in regard to the methods of procuring and distributing water, and the precaution that advanced civilization demands should be taken toward the purification of our drinking waters, I think I may safely say you are much more familiar with them than I. What I have had to do in my official capacity, serving upon the water committee of the legislature for two years, has looked more to quantity, perhaps, than to quality of water. We endeavored, so far as we could, when we had petitions before our committee, to use the parties who came to us with their applications in a fair manner. Where two towns came in and claimed the same source of supply, we endeavored, so far as we could, to discover who had the best right, and while, perhaps, our judgment and decision did not always satisfy everybody, we certainly in most instances satisfied one of the parties, and that was doing pretty well.

The water question is a question which is engrossing the attention of the people of our Commonwealth more and more every year. In considering this matter in a legislative way it was sometimes difficult to determine where the demand for water would end. We often came across this difficult problem to solve. Communities would come in and ask for a source of supply, and we would find that in order to give them what they asked for we in some cases would have absolutely to wipe out of existence some of the best

property in the State. It was a serious question whether we should destroy valuable mill property in order to give people what they ought to have to drink. When you take away water that is used for power, that is something that can be compensated for to a certain extent. But many of these large mill corporations need to use the water for washing purposes in the manufacture of their woolen goods; and it was a very serious question and it often made me think that if the thing kept on many of our valuable mill properties would be entirely destroyed. Of course it was always provided that the community taking water should make compensation to the owners, and oftentimes, I have no doubt, when the owners received the compensation, they got all that they were entitled to; but having received that compensation there was then nothing to prevent them from folding their tents and silently stealing away, and the community which had had the benefit of a large manufacturing industry might be deprived of it. That is one of the things that made us stop and consider where this demand for water supply was tending. Of course the first thing for consideration is that the people shall have water; an abundance of water of good quality; the very purest and best water possible to obtain; that is certainly the first consideration, and we did give them all that we could in that way. But there is this other thing to take into consideration, and I think it is something that should engage our attention.

I was therefore glad when this grand scheme, this scheme of large proportions, the Metropolitan Water Supply, was talked of, because it seemed to me that might possibly eliminate this great problem we have to consider. As I understand the Metropolitan Water Supply is to be taken from the hill towns, from a country that is sparsely inhabited, where there are fewer of these valuable mill rights than there are in many sections, and a country which is amply able to supply a large amount of water sufficient to meet the needs for a very long time. I think the estimate is, when the upper and lower Ware and the Swift river watersheds are developed, the supply will be sufficient for a population of 5,000,000 of people.

Now, Mr. Chairman, I beg your pardon for taking up so much of your time, for I feel as though I were intruding upon the business which has called you together this afternoon.

The regular program for the afternoon was then proceeded with. Fred. G. Perry, Assistant Commissioner of Public Works, Paw-

tucket, R. I., read a paper on "Pressure Recording Gauges." The subject was discussed by Mr. Whitney, Mr. Haskell, Mr. Fuller, Mr. Holden, Mr. Richards and Mr. Chase. Frank L. Northrop gave a description of the Filtering Gallery of the Milford Water Works, and answered questions which were asked by Mr. Chace, Mr. Haskell, Mr. Thomas and Mr. Fuller. Mr. Coggeshall presented a paper entitled "An Experience with Anchor Ice." Mr. Richards, Mr. Hale, Mr. Sparks and Mr. Stacy also gave experiences. Mr. Haskell, of Lynn, read the closing paper, his subject being "Electrolysis," and the subject was further discussed by Mr. Holden, Mr. Coffin and others.